# The effect of grassland shifts on the avifauna of a South African savanna

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## Abstract

Two distinct grassland types occur within Hluhluwe-iMfolozi Park (HiP); short stoloniferous grazing lawns and tall, tussock-like 'bunch' grasslands. Grazing lawns are maintained by grazing mammals, among which White Rhinoceros *Ceratotherium simum* is of major importance. By contrast, tall bunch grasslands are promoted by frequent burning. The extent of each grassland type within the park is highly dynamic and can be altered by changes in mammal numbers and/or fire regimes. Such changes may have cascading consequences on other components of the ecosystem if they show specialisation towards one or other grassland state. This study compared avifaunal assemblages of grazing lawns and bunch grasslands to assess how bird species of the park might change with shifts in the grassland mosaic. Distinct bird communities were associated with each grassland type, including several specialists, and bird distribution was linked to vegetation structure, rather than floristics. Post-fire bunch grasslands provided ephemeral habitats for short grass specialists. Outside HiP, domestic livestock produced structurally similar grasslands to grazing lawns and bunch grasslands, but heavy predation of birds by people reduced bird densities. Because HiP is surrounded by such communal grazing lands, the park is of key importance in conserving grassland birds on a regional scale, a factor that needs to be considered in managing the park's grassland mosaic.

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# Chapter 1: Introduction

Hluhluwe-iMfolozi Park (HiP) has two distinct grassland types, tall tussock 'bunch' grasslands and short stoloniferous grazing lawns (Figure 1.1). These grasslands form an integral part of the park's continually changing landscape. From a conservation standpoint, it is important to understand not only how these grasslands are formed and maintained, but also how animals use them.

**Figure 1.1:** *Illustrates grazing lawns on the left and bunch grasslands on the right.*

Grazing lawns appear to be maintained by grazing mammals, while tall bunch grasslands are promoted by frequent fire. These grasslands are highly dynamic and the mosaic in which they occur is determined by grazing pressure and fire regimes(Archibald *et al.* 2005). They not only provide a valuable food source for many herbivores, but are also an important habitat for birds.

A comparison of avifauna of the 1970s with that of the area in historical times, found that a high proportion of grassland bird species had become locally extinct (Macdonald 1984), several of which frequented short-grass habitats. The majority of these species are known to be nomadic, migratory or on the edge of their range. However, their disappearance nonetheless strongly suggests that some change has taken place. It is possible that this change has occurred beyond the park boundaries, but it may equally well be a response to habitat changes within the park. If the latter is the case, an understanding of the processes responsible would be of great value to conservation managers and provide insight that may help prevent further biodiversity loss.

In South Africa (and elsewhere) rangeland scientists have, in the past, perceived grazing lawns as products of overgrazing and mismanagement and considered tall *Themeda triandra* bunch grasslands as 'ideal veld'. The presence of 'overgrazed' patches prompted managers to reduce grazing pressure in an effort to convert short-grass areas to tall bunch grasslands. This was achieved by large-scale culling and game-capture operations. Recent studies (Zululand Grass Project, unpublished) have shown that grazing lawns are highly productive under intense grazing pressure. They are floristically different from tall bunch grasslands and support a high density and diversity of grazing herbivores. This suggests that they have a long evolutionary association with grazing herbivores and are a normal component of the African savanna. Evidence exists to suggest that drought, fire and mammal removal may have influenced the extent of grazing lawns in HiP since the 1960's (Bond *et al.* 2001). This is particularly evident in Hluhluwe, where long-term monitoring has shown dramatic changes from short grass in the late 1960's to tall grass swards in the 1980's. White Rhinoceroses *Ceratotherium simum* are primarily responsible for maintaining grazing lawns in the northern higher rainfall areas of HiP (MS Waldram pers. comm.). Thus, even though the rhinoceros population of the park is increasing (HiP park records), removal of many animals in the late 1970's and early 1980's resulted in low densities. Removal of rhinos and other grazers may have been responsible for the decrease and disappearance of grazing lawns in the northern part of the park.

Similarly, fire return intervals of less than fours year may reduce grazing lawn formation in HiP, by indirectly reducing the density and diversity of large mammal species on grazing lawns (Archibald *et al.* 2005). After a fire event, herbivores are attracted to the post-burn flush of new growth and consequently drawn off heavily grazed patches. Very small fires may concentrate grazers which might initiate a grazing patch but the normal large fires will pull grazers off grazing patches and cause the herbivores to spread out on the large burnt areas and thus have a less concentrating effect. In the long term, frequent large fires will indirectly reduce the density and diversity of large mammals species on grazing patches, and reduce lawn grass formation because grazers would not persist in a grazing patch long enough to cause a compositional shift from tall grass to lawn grass species. Consequently, the current high-frequency fire regime may have contributed to the decrease in grazing lawns.

This study compares the avifaunal assemblages associated with grazing lawns and bunch grasslands to assess how bird species composition within the park might change with

changing proportions of the two grassland types. The study also compares the bird assemblages of post-burn bunch grasslands that resemble grazing lawns in the early stages of post-burn re-growth, and heavily grazed communally farmed areas outside the park. These may provide an alternate habitat to grazing lawns within the park.

The objectives of this study were:

1. To investigate which bird species characterise grazing lawns and bunch grasslands habitats within HiP.
2. To investigate whether the incidence and abundance of grassland birds is a function of the physical structure of the vegetation or a response to its floral composition.
3. To investigate which bird species characterise post-burn bunch grasslands.
4. To investigate which bird species characterise communal lands surrounding HiP.
5. To use this information to recommend conservation strategies for grassland birds within the HiP.

## Thesis Outline

In Chapter 2 I provide a detailed description of the study area from a geographical and management perspective. Chapter 3 reports on an analysis of grassland bird communities in the park. In this chapter, I identify grassland specialists by comparing the presence and abundance of birds not only in grassland habitats but also of other habitat types in the reserve. Chapter 4 is an investigation of bird species that make use of recently burnt grassland swards, since the post-burn condition of tall grasslands is structurally similar to grazing lawns. It is feasible that frequent burning might create the necessary habitat conditions to support "short grass" bird specialist species. Alternatively, the post-burn recovery might be too rapid to provide suitable habitat requirements for these birds. In Chapter 5 I compare birds in the grasslands outside the park and with those found inside the park. The areas outside the park are under communal tenure and typically heavily grazed by domestic livestock. It is therefore possible that, though rare within the park, short grass swards would be abundant outside the park, providing large areas of suitable habitats for grassland specialist birds. In Chapter 6, I report on bird predation by people. This followed, after finding very low bird abundances outside the park (from Chapter 5). I wished to explore whether predation could be a significant factor accounting for low bird

abundance in the communal farming areas. In Chapter 7, I report an analysis of the distribution and size of grazing lawns in the park and their suitability for grassland bird conservation. I calculated species area requirements to explore the area of grassland necessary to support viable populations of specialist species and related these estimates to actual lawn distribution. The final chapter is a synthesis of the results with management recommendations

## Note to the reader

Each chapter has been prepared as an individual report. Thus, some repetition was necessary to explain concepts and ideas in each Chapter. However in situations where the same survey techniques were used in different aspects of the study, they have not been re-described. All scientific names for bird species are listed in Appendix A at the end of the thesis.

# Chapter 2: Site Area

Hluhluwe-iMfolozi Park (HiP) is located in northern KwaZulu-Natal, eastern South Africa (28°00'-28°10' S, 32°00'-32°10' E). Once the exclusive royal hunting ground of King Shaka, and the former Hluhluwe and Umfolozi Game Reserves, this area is now enclosed by an electrified fence that separates it from the surrounding human population (Figure 2.1). It covers an area of 960 $km^2$ and has a subtropical climate with variable topography, ranging from 40-580 m asl. The higher northern section of the park has an average annual rainfall of 985 mm, decreasing to 650 mm p.a. in the southern section. The majority of the rain falls from October to March, with a daily mean minimum temperature of 13°C and a daily mean maximum of 35°C (Greyling & Huntley 1984).



## Geology

The geological structure of the park is characterised by intense fracturing and faulting, which occurred during both the Gondwana break-up (180 mya) and the final drifting (140 mya). The rock strata is tilted, exposing the older rocks of 3200 my in the west. Most of the major rock series of Kwazulu Natal are represented, with Karoo sediments being most widespread. The varied topography, climate and geology has resulted in a wide variety of soil types (King 1970)

## Mammal fauna

HiP supports a broad spectrum of mammals, including African Elephant *Loxodonta afrciana*, Black Rhinoceros *Diceros bicornis*, White Rhinoceros, *Ceratotherium simum*, Cape Buffalo *Syncerus caffer*, Lion *Panthera leo* and Leopard *Panthera pardus*, with a full compliment of other herbivores, carnivores and small mammals.

Herbivore numbers in particular have undergone great fluctuation since the park's proclamation in 1895 (Brooks & Macdonald 1983). An outbreak of rinderpest *Morbillivirus* in the late 1800s dramatically reduced game numbers which were reported to have only recovered in 1905 (Brooks & Macdonald 1983). Similarly the

anti-ngana *Trypanosoma congolense* campaign from 1916 to 1950 resulted in the extermination of 96 000 animals (Brooks & Macdonald 1983). The removal, either by shooting or capture, in the 1950s and late 1960s to early 1980s also resulted in reductions in numbers of Burchell's Zebra *Equus burchelli*, Blue Wildebeest *Connochaetes taurinus*, Warthog *Phacochoerus aethiopicus* and White Rhinoceros, in an effort to revert 'overgrazed' areas into tall bunch grasslands (Brooks & Macdonald 1983).

## Vegetation

The vegetation is dominated by savanna woodlands, with some evergreen forests and grasslands (Whateley & Porter 1983). Acocks (1988) classifies HiP into the Zululand Thornveld, Coastal Tropical Forest and Lowveld Tropical Bush and Savanna veld types. Low & Rebelo (1996) classifies HiP into Afromontane Forest, Natal Central Bushveld, Natal Lowveld Bushveld and Coast-Hinterland Bushveld.

Qualitative and semi-quantitative accounts of the vegetation of the Hluhluwe-iMfolozi Park have indicated that gross structural changes have occurred since its proclamation as a protected area (see Bond et al. 2001; Brooks & Macdonald 1983; Deane 1996; Downing 1980; Macdonald 1979; Macdonald 1983; Skowno et al. 1999; Vincent 1970; Watson & Macdonald 1983a; Watson & Macdonald 1983b). These include a progressive increase in both tree and shrub cover, at the expense of grassland and savanna areas, invasion by alien pla nt species such as Trifffid Weed *Chromolaena odorata*, and changing proportions of the two alternate grassland states (short stoloniferous grazing lawns and tall tussock like 'bunch' grasslands). These grassland shifts are particular evident in Hluhluwe, were where long-term monitoring has shown dramatic changes from short grass in the late 1960s to tall grass swards in the 1980s. For example, (Bond et al. 2001) noted that the dominant tree species in Hluhluwe, an area of over 30 000 ha, had been replaced by different sapling species. This was thought to have been associated with a switch from short to tall grass because species with herbivore-tolerant saplings have been replaced by species with fire-tolerant saplings.

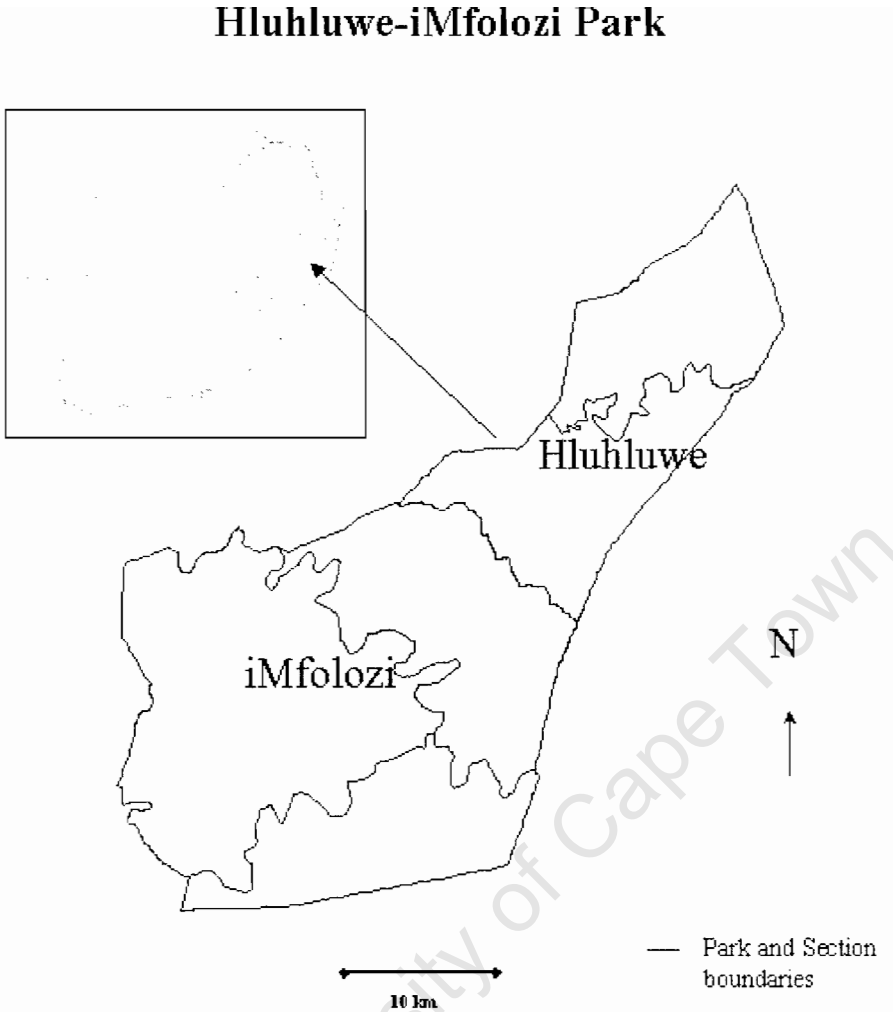




**Figure 2.1:** *Map showing the location of Hluhluwe-iMfolozi Park and the different sections.*

## Avifauna

According to Winterbottom's (1974) classification of avian zoogeographical regions. HiP falls within the Southern Sub-district of the East African Coastal District, but is close to the convergence point of four districts:

1). South Central Highlands District.
2). East African Coastal District – Mozambique Sub-district.
3). East African Coastal District – Southern Sub-district.
4). South Temperate District – Highveld Sub-district.

This convergence may explain the exceptionally high avifaunal diversity of more than 400 indigenous bird species that have been recorded in the Park, of which *ca* 326 species are considered to occur regularly (Macdonald & Birkenstock 1980).

There is little avifaunal information about HiP prior to the 1960s, with the only records being unannotated checklists of park rangers. In the 1960s, Owen-Smith (1980) kept semi-quantitative records from iMfolozi. The best records stem from a study by Macdonald (1984). He compared birds recorded from 1970-1979 with those of previous years. His findings suggested that 54 species had become locally extinct by the 1970s, 25 of these were grassland species (Table 2.1). Many of the species that have apparently become locally extinct were formerly only present sporadically within HiP, or are known to be rare migrants, but the reason(s) for the disappearance of formerly resident species remains unknown. Macdonald (1984) suggests several possible reason for their extinction, none of which has been tested. Firstly, he suggested that the grassland habitats in the matrix surrounding the park have deteriorated and the losses are responses to these habitat changes outside the park boundaries Secondly, the extent of grassland habitat within HiP has always been small, and that the observed decrease in species diversity along with a further decrease in grassland area as a result of game management, is simply that predicted according to Island Biogeography Theory. Thirdly, a high proportion of the locally extinct species are ground nesters and it was thought that their eggs and offspring are being heavily depredated by the unusually high numbers of Vervet Monkey *Cercopithecus aethiops* , Chacma Baboon *Papio ursinus* and Pied Crow. Lastly, it

was suggested that the 1970s was a wet period with above-average rainfall and that several of the species may return in drier years.

Subsequent to Macdonald's (1998) investigation, African Marsh-Harrier, Senegal Lapwing and Temminck's Courser have been recorded on rare occasions, but it is really only the African Pipit that has been regularly observed.

**Table 2.1.** *A list of locally extinct grassland species in HiP, as judged by their absence over the period 1970-1979 (Macdonald 1984; Macdonald & Birkenstock 1979). Resident species are highlighted.*

| Common name | Habitat | | Breeding status |
|---|---|---|---|
| Abdim's Stork | Grassland | Savanna | Intra-African Migrant |
| **African Marsh-Harrier** | **Grassland** | | **Resident** |
| Pallid Harrier | Grassland | | Palaeartic Migrant |
| Greater Kestrel | Grassland | Savanna | Nomad |
| Harlequin Quail | Grassland | Savanna | Intra-African Migrant |
| Blue Quail | Grassland | | Intra-African Migrant |
| Corn Crake | Grassland | | Palaeartic Migrant |
| Denham's Bustard | Grassland | Savanna | Intra-African Migrant |
| Ludwig's Bustard | Grassland | Savanna | Nomad |
| Senegal Lapwing | Grassland | Savanna | Intra-African Migrant |
| Temminck's Courser | Grassland | Savanna | Nomad |
| Black Coucal | Grassland | | Nomad |
| African Grass-Owl | Grassland | | Nomad |
| Marsh Owl | Grassland | | Nomad |
| Red-capped Lark | Grassland | | Nomad |
| Chestnut-backed Sparrowlark | Grassland | Savanna | Nomad |
| Grey-rumped Swallow | Grassland | | Nomad |
| **Sentinel Rock Thrush** | **Grassland** | | **Resident** |
| Capped Wheatear | Grassland | Savanna | Nomad |
| Broad-tailed Warbler | Grassland | | Nomad |
| **African pipit** | **Grassland** | | **Resident** |
| **Long-billed Pipit** | **Grassland** | | **Resident** |
| Wattled Starling | Grassland | | Nomad |
| Long-tailed Widowbird | Grassland | | Nomad |
| Brimstone Canary | Grassland | | Nomad |



## Fire

The fire regimes of HiP have varied since the park's proclamation. The frequency and size of the fires have been affected by the variation in fuel loads during wet and dry rainfall periods and by fire management policies. In the 1930s and 1940s, fire was largely excluded from the iMfolozi area to prevent the wooden tsetse fly traps from burning (Vincent 1970), while elsewhere winter burning was implement to improve

grass quality for grazers (Vincent 1970). In the 1950s, fire was used as a tool to control encroachment of several *Acacia* species (Brooks & Macdonald 1983). From the 1960s onwards, burning frequency was determined by available fuel loads, with the primary aim to provide grazing for herbivores and reduce encroachment. These fires were initially implemented as block burns, but this changed in the 1980s to point ignition, as this would create a more heterogenous environment (Balfour & Howison 2001).

The area of the park that burns in a year has ranged from 0 to 80 000 ha (90% of the park). In recent years there has been a general increase in area burnt and at present between 30 and 50 percent of the park is burnt in any one year (Archibald 2003). The mean fire return period for the park, over 41 years, is 3.8 years, and the median fire return period is considerably shorter at 1.3 years (Balfour & Howison 2001)

# Chapter 3: Effect of vegetation structure on grassland bird community composition within Hluhluwe-iMfolozi Park

## *Introduction*

Qualitative and semi-quantitative accounts of the vegetation of the Hluhluwe-iMfolozi Park have indicated that gross structural changes have occurred since the park's proclamation (see Bond et al. 2001; Brooks & Macdonald 1983; Deane 1996; Downing 1980; Macdonald 1979; Macdonald 1983; Skowno et al. 1999; Vincent 1970; Watson & Macdonald 1983a; Watson & Macdonald 1983b). These include a progressive increase in both tree and shrub cover, at the expense of grassland and savanna areas, invasion by alien plant species such as Trifffid Weed *Chromolaena odorata* and changing proportions of the two alternate grassland states (short stoloniferous grazing lawns and tall tussock -like 'bunch' grasslands) (Macdonald 1983; Watson & Macdonald 1983b). These grassland shift are particularly evident in Hluhluwe, where there have been dramatic changes from short grass in the late 1960s to tall grass swards by the 1980s (Bond *et al.* 2001).

Climatic changes, fire regimes and fluctuations in herbivore numbers may all contribute to changes in the spatial extent of the two grassland states (Archibald *et al.* 2005; Bond *et al.* 2001). Although conservation managers are unable to alter climatic fluctuations, fire and herbivore numbers can and have been used as tools to manipulate the landscape (Anderson 2003; Whateley & Porter 1983). Low-frequency fire regimes and/or high herbivore number are thought to assist in the formation of grazing lawns. Conversely, frequent fires and/or low herbivore numbers retard the formation of grazing lawns and promote tall bunch grasslands (Archibald *et al.* 2005). If these grassland states are to be managed effectively to maintain biodiversity within the Park, it is important to document and interpret differences in the biodiversity characteristics of the two grassland states.

The physical structure of a habitat has long been considered an important niche dimension for birds (Folse 1982; Knopf *et al.* 1988; Wiens & Rotenberry 1981). It provides nesting substrata, courtship and display stations, protection from predators

and shelter from physiological stresses. It also provides potential cues to the availability and diversity of prey and other conditions necessary for successful reproduction (Hilden 1965; Wiens 1969).

Understanding habitat relationships of birds and how species assemble to form communities is a critical component of bird and habitat conservation. Numerous studies since the early 1960s have linked various aspects of vegetation structure with avian diversity and community organisation (MacArthur & MacArthur 1961; MacArthur *et al.* 1962; Ralph 1985; Roth 1976; Wiens & Rotenberry 1981; Willson 1974). In South Africa Jansen (2001) and Skowno & Bond (2003) looked at the effect of habitat change on bird diversity. I wish to investigate changes in bird densities and assemblages within the alternate grassland states found in HiP, namely grazing lawns and bunch grasslands found in HiP.

Grazing lawns develop when tall bunch grasslands are heavily utilised by herbivores. Bunch grasslands are grazed down into a 'grazing patch', if grazing within such a patch persists, the grazing patch undergoes a compositional grass species shift from short grazing intolerant caespitose bunch-grass species to short, stoloniferous, grazing-tolerant species. This golf course like grassland is termed as a 'grazing lawn'. These two alternative grassland states (bunch grasslands and grazing lawns) are structurally and floristically very different, and may support different bird communities. Should this be the case, shifts in the grassland state may be beneficial to some taxa and detrimental to others.

This chapter sets out to identify:

1. Whether different bird species characterise grazing lawns and bunch grasslands within HiP.
2. Whether these bird species make use of other habitats, or if they are restricted to a particular grassland state.
3. Whether the incidence and abundance of grassland birds is a function of the physical structure of the vegetation or a response to its floristic composition, or both.

These results will not only provide valuable insight into the grassland birds of HiP, but may provide guidance on the consequences, for this component of the Park's biodiversity, of management policies with regards to of fire regimes and herbivore removals.

## *Field Methods*

### Quantifying Bird populations

Several techniques exist to count terrestrial birds. These can be categorised into two main groups: methods that use counts as an index of relative abundance, and methods that use empirical modelling to estimate bird density directly. This study makes use of both.

Line transects are mainly used to collect data in large open areas because they tend to record more birds per unit time than point counts. In contrast, point counts are used in dense habitats as it is often difficult for an observer to detect birds while moving (Bibby *et al.* 2000). Line transects were used to quantify the grassland bird species, and point counts to identify which of the birds identified within the grasslands made use of other habitats.

**Birds in open grasslands**

Potential sampling sites were initially identified using a classification map of grass communities derived from a 1999 Landsat TM image (Archibald 2003). Whilst it was possible to distinguish between short and tall grasslands on this map, potential sites had to be ground-truthed in order to characterise them within the grassland continuum as some areas had undergone transformation since 1999. Sites heavily invaded by woody plants were not selected, primarily because such plants attract birds that are not true grassland species. Twenty-four open grassland sites (12 short grass and 12 tall grass sites), of varying size, were selected across the rainfall gradient to include the full range of grassland habitats within HiP. The location of the sites is shown in Figure 3.1. Surveys were started in August 2003 and took place every 2 months over a period of one year. This allowed for the monitoring of bird presence, absence and abundance with seasonal vegetation changes, and took into account seasonal migrants.

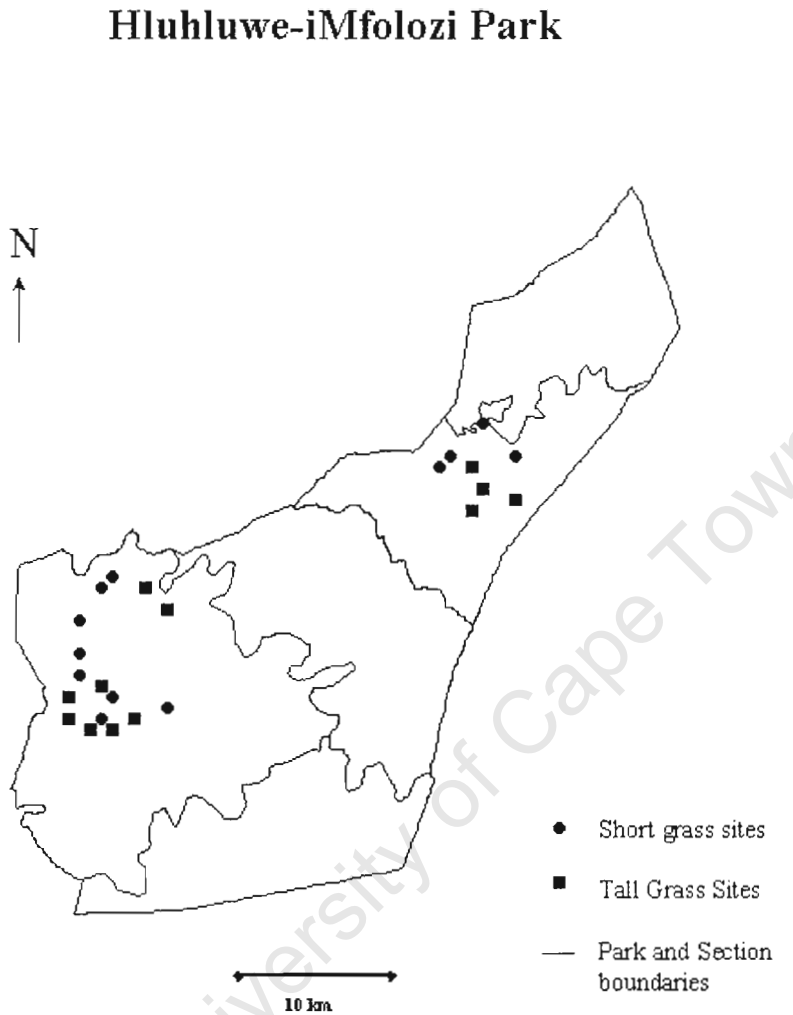




**Figure. 3.1:** *Map of Hluhluwe-iMfolozi Park showing study sites, park boundary and section boundaries*

At each study site, a fixed transect that traversed the longest axis was marked. This transects varied in length from 100 m to 300 m, depending on the size of the study patch. The beginning and end point of these transects were demarcated with metal pegs, to ensure the same route was traversed during each sampling period. Avian species accumulation curves were constructed during preliminary studies in July 2003: these indicated that each transect needed to be sampled a minimum of four times during each sampling period. Sites were therefore surveyed four times on two consecutive days. Sampling took place during the first two hours after sunrise and the last two hours before sunset. When rain or wind appeared to affect bird activity or detectability, sampling was terminated. Data from these temporal replicates were pooled and treated as a single sample for each site.

Bird survey techniques were modified to suit each grassland type:

*a) Short grass swards*

Bird density data were collected using the standard method for line-transect sampling (Buckland *et al.* 2001). A slow, steady pace was walked, all birds seen within the study area identified and the perpendicular distance from the transect line to the position of each bird when first detected was estimated (Figure 3.2). To improve the accuracy of the distance measurements, permanent markers were installed at known distances from the transect line. In situations in which species occurred in flocks, the distance to the centre of a group was estimated, and the number of individuals noted. Aerial feeders, such as swifts, swallows and martins, as well as raptors, were excluded.

*b) Tall grass swards*

The above technique was unsuitable in tall grass areas, because most birds were hidden within the grass. Densities were therefore assessed using a rope-drag transect of 30 m width, sited according to the same criteria used in lawn grass areas (Figure 3.3.).

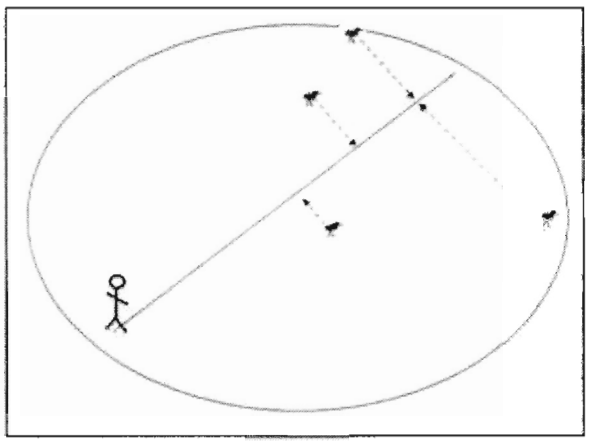

**Figure 3.2:** *Line transect. All birds sighted within the study area are identified and the perpendicular distance to the transect line estimated.*



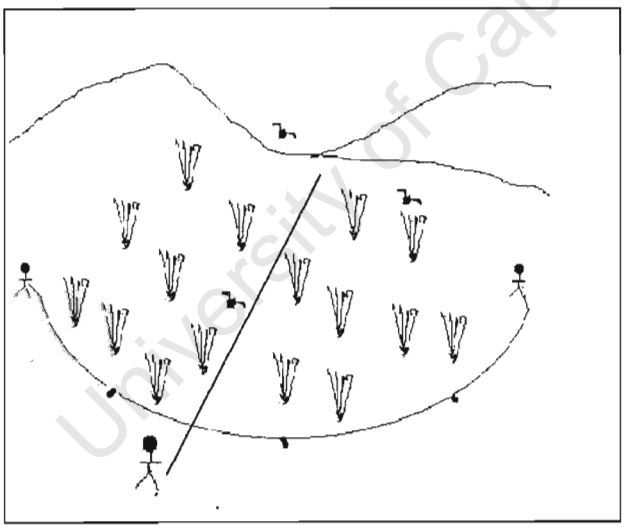

**Figure 3.3:** *Rope-drag transect. A weighted 30 m rope was dragged through grass swards; flushed birds are identified and counted*

**Birds in other habitats**

In order to determine whether species observed in grassland sites were habitat specialists or used other, more wooded habitats, additional samples were taken in different habitat types. Using a vegetation map created by Whateley & Porter (1983), woody vegetation types that support a grass layer were grouped into low-, medium - and high-density woodlands, and thicket. Ten random sites within each of these habitat types were selected. A total of four, 10-minute point counts (Bibby *et al.* 2000) were conducted at each site and all birds seen and heard within a 100 m circular radius were recorded. This was done in the morning and afternoon of two consecutive days in January 2004 (Figure 3.4). Only presence/absence data were collected, because the purpose of this survey was solely to establish which of the birds observed in the grasslands were not grassland specialists.

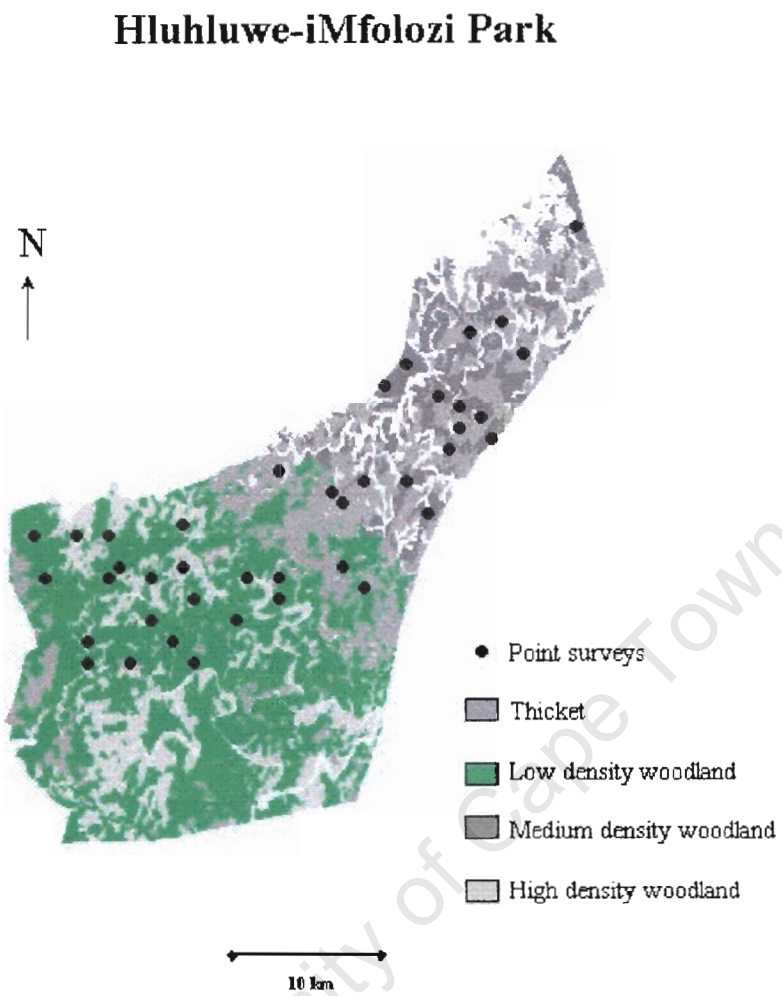




**Figure 3.4:** *Map of Hluhluwe-iMfolozi Park showing point count bird survey sites in low, medium and high density woodlands and thicket habitats*
*Adapted from Whateley & Porter (1983)*

## Characterising vegetation

The following information was collected for each grassland site:

1. Grass species composition
2. Tree species composition
3. Foliage biomass
4. Horizontal foliage diversity and the amount of bare ground
5. Foliage height profiles

Grass and tree species composition for each study site was determined once during the study. The dominant grass species were identified at 1 m intervals along the first 100 m of the transect used for the bird surveys. Preliminary species accumulation curves suggested 100 m was sufficient to identify common grass species within the study site. The primary purpose of this was to determine which grass species characterise the two grassland types, and to determine which of the short grass areas were grazing lawns or grazing patches. In patches that contained woody plants taller than the grass sward, the tree composition and density were determined using the Wandering Quarter technique (Catana 1953)

Structural diversity was assessed using three techniques, two quantitative (Disc Pasture Metre and Foliage Height Profiles) and one-semi quantitative (Intercept Method). An index of foliage biomass was obtained using a Disc Pasture Meter (DPM) (Bransby & Tainton 1977). A total of 50 points were sampled per transect, at 2 m intervals along the first 100 m of the transect. Horizontal foliage diversity of vegetation height, density and amount of bare ground were determined using the Intercept Method, designed specifically for this study. This consisted of recording ground cover at 1 m intervals along the fixed transect as follows:0 = bare ground 1 = grass < 50 mm high, 2 = grass 50-200 mm, and 3 = grass >200 mm. The three grass layers were clearly distinct in the field. In all patches, the minimum number of sample points was 150. Their relative percentages gave a spatial index of bare ground, short grass swards, medium grass swards and tall grass swards. Data using the Intercept Method and Foliage Biomass Index were collected every 2 months for a period of 1 year (August 2003 to July 2004) after each grassland bird sampling period.

In addition, the amount of vegetation at different heights was assessed with foliage height profiles (MacArthur & MacArthur 1961) along the fixed transects. The same method was used by Skowno & Bond (2003) in HiP. I estimated the distance at which 50 percent of a 30 cm x 30 cm white board was obscured by foliage at 0, 0.25, 0.5, 0.75, 1 and 1.5 m above ground from the four cardinal directions. This was done every 10 m along the first 100m of the transect. This technique was very time consuming and data were collected only in the middle of the dry season (August 2003) and the middle of the wet season (February 2004).

## *Analytical methods*

In tall grass swards it was assumed that all birds within the strip were flushed by the rope-drag technique, hence calculations of density were simply a matter of dividing the total number of birds seen within the strip by the strip area. For short grass sward areas, the software DISTANCE (Laake *et al.* 1994) was used to calculate densities. This technique was favoured because it can account for difference in conspicuousness between species based on distance-incidence functions, and thus uses a detection function to calculate density. This is critical as not all birds were seen while walking the transect.

Buckland *et al.* (2001) prescribe the necessary exploratory analyses of the field data to look for evidence of evasive movement of birds before detection, rounding and heaping of data and to check if truncation is necessary for outlier observations. For example, the African Pipit data set showed evidence of evasive movement before detection, with highest detection at 10 m rather than at 0 m. A Hazard Rate Model (Buckland *et al.* 2001) was employed to change the line of best fit from a third order to a second order best-fit curve, forcing the curve not to peak at 10 m but decrease slowly from 0 m (Figure 3.5).

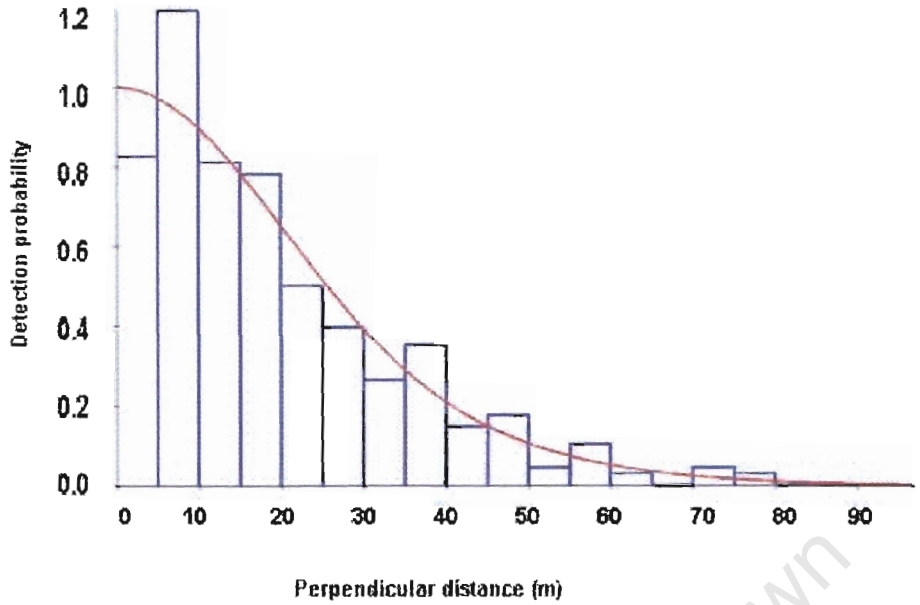


**Figure 3.5:** *Evidence of evasive movement before detection in the African Pipit data. The Hazard rate model was selected to correct for this problem.*

The best possible model was fitted to each bird species dataset using Akaike's Information Criterion (AIC) values. Although the techniques for estimating density in the tall and short grass swards differ, both estimate density, and their results are thus statistically comparable.

Bird species diversity for each site was calculated using the Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i$$

s = total number of species

$p_i$ = observed proportion of individuals that belong to the ith species

This index is influenced by the number of species present and the evenness of their distribution; increasing values of H' reflect higher species diversity. A one way

ANOVA with grass type as the categorical predictor was used to test for differences in species number, density and diversity between the tall and short grass areas.

True habitat specialists were identified from presence /absence data from all sample sites. These were species that occurred significantly more often in the grassland types than in other habitats as tested by Fisher's exact probability test using the software STATISTICA (StatSoft, Inc. 1984-2003).

I used Detrended Correspondence Analysis (DCA) to determine if different bird communities occur at either end of the grassland continuum. DCA was used as it is a more reliable method than reciprocal averaging and principle component analysis (Hill 1979) because it avoids the arch effect (Gauch 1982). This multivariate data-reduction and ordination technique spatially arranges a matrix of species abundance and composition data or habitat variables by site. The position of each site is plotted using DCA scores for the first and second axes, as these two axes account for the greatest proportion of the variation in the original data set. Each axis may represent some identifiable environmental gradient. Hence, the DCA score represents the position of the site along these environmental gradients. For example, sites that share similar bird communities will be close together and dissimilar sites will be far apart.

Bird species replacement from site to site (turnover) along a gradient of increasing grass height, was firstly illustrated by plotting the number of species lost and/ or gained against sites of varying grass height, and secondly by plotting ß-diversity against a gradient of increasing grass height. Wilson and Schmida's formula (1984) was used to determine ß-diversity:

**ß = [ g(H) + l(H) ]/2a**

ß = the beta diversity between sites of different grass height
g(H) = the number of species gained along the gradient H
l(H) = the number of species lost along gradient H
a = the mean sample richness of all the samples along the gradient.

A Detrended Canonical Correspondence Analysis (DCCA) was used to relate bird communities identified in DCA, or specialists identified from Fisher's exact test, to

structural habitat variables and plant species composition. This will indicate whether the incidence and abundance of bird species is a function of plant species composition or vegetation structure. For example, short grass sites may be true grazing lawns consisting of short stoloniferous grass species, or a grazing patch consisting of shortly grazed caespitose bunch grass species. Thus if short grass inhabiting birds are present at both grazing lawns and grazing patches it is likely they are responding to some structural variable rather than the grass species composition. Conversely if they only occur on grazing lawns, they are likely to be sensitive to changes in grass species composition. Because there are so many possible variables to consider, a DCCA is used to help enhance the interpretation of environmental gradients and allow for individual species to be related to all major environmental factors (Kent & Coker 1997).

The computer program CONOCO for windows (version 4.02) was used for all ordinations.

The associations displayed in the ordinations were examined using a generalised linear model (GLM) in the software JMP (version 5.0.1.2.) using the scores from axis 1 and 2 from the DCCA as the dependant variable with habitat variables as the independent variables. GLMs quantify the relative significance of vegetation characteristics, such as floristics and structure, as predictors of avian communities in the grasslands, by noting changes and associated probability values in the coefficient of determination ($R^2$) as variables are sequentially added.



## *Results*

### Vegetation

Structural habitat variables at each site varied throughout the year, according to season, recent rainfall and grazer activity. Structural vegetation characteristics are displayed in Appendix 3.1. The majority of tall grass site were dominated by *Themeda triandra*, while short grass sites in Hluhluwe were dominated by *Digitaria longiflora* and in iMfolozi by *Digitaria argyrograpta* (Table 3.1). Some short grass sites had a

high proportion of non-stoloniferous species and thus were considered grazing patches rather than grazing lawns. Tree species composition varied from site to site (Table 3.1).

**Table 3.1:** *Area (ha), dominant trees species and dominant grass species of each study site*

| | | | |
|---|---|---|---|
| HB1 | 10.0 | *Acacia nilotica/Dichrostachys cinerea* | *Themeda triandra* |
| HB2 | 40.0 | *A. nilotica/D. cinerea* | *T. triandra* |
| HB3 | 30.0 | *A. nilotica/D. cinerea* | *T. triandra* |
| HB4 | 25.0 | *A. nilotica/Gymnosporia senegalensis* | *Sporobulus pyramidalis/Eragrostis curvula* |
| HL1 | 1.4 | *A. nilotica/D. cinerea* | *Eragrostis curvula/Dactyloctetium australe* |
| HL2 | 16.3 | *D. cinerea* | *Digitaria longiflora* |
| HL3 | 4.0 | *D. cinerea* | *D. longiflora* |
| HL4 | 3.1 | *D. cinerea/G senegalensis* | *Digitaria longiflora/Sporobolus pyramidalis* |
| UB1 | 23.0 | *Acacia nigrescens* | *T. triandra* |
| UB2 | 2.0 | *Acacia tortilis* | *T. triandra* |
| UB3 | 4.0 | *A. tortilis* | *T. triandra* |
| UB4 | 7.0 | *A. tortilis* | *T. triandra* |
| UB5 | 12.0 | *A. tortilis* | *T. triandra* |
| UB6 | 15.0 | *A. tortilis* | *T. triandra* |
| UB7 | 2.5 | *A. nigrescens* | *T. triandra* |
| UB8 | 3.1 | *A. nigrescens* | *T. triandra* |
| UL1 | 1.9 | *Acacia robusta* | *Sporubolus nitens/Sporobolus ioclados* |
| UL2 | 8.0 | *Acacia tortilis* | *Digitaria argyrograpta* |
| UL3 | 6.5 | *D. cinerea* | *T. triandra* |
| UL4 | 12.1 | *A. tortilis* | *D. argyrograpta* |
| UL5 | 9.0 | *A. tortilis* | *D. argyrograpta* |
| UL6 | 6.9 | *Acacai grandicornuta/A. tortilis* | *Sporubolus nitens/Sporobolus ioclados* |
| UL7 | 2.4 | *A. nigrescens* | *D. argyrograpta* |
| UL8 | 25.0 | *A. nigrescens* | *D. argyrograpta* |
| **Mean** | **11.3** | | |

H = Hluhluwe, U = iMfolozi, B = tall grass, L = short grass

Note: The sites are grasslands areas; trees are only present at very low densities



## Bird abundances in the different grassland states

The abundances of all birds detected in each of the grassland sites are presented in Appendix 3.2. A total of 87 bird species were encountered within the grasslands, with short grass areas supporting 74 species and tall grasslands 59.

An ANOVA (Table 3.3) indicated that the differences in the species richness and diversity between the short and tall grass areas were significant, with short grass areas

having higher species richness and diversity. No significant difference was detected in overall densities of all species combined.

**Table 3.2:** *Mean species richness, density and species diversity (H') for all birds detected at each site.*

| Site | Spp. Richness | Density | Spp. Diversity |
|---|---|---|---|
| **Tall grass sites** | | | |
| ub6 | 25 | 6.1 | 4.0 |
| ub1 | 27 | 11.5 | 3.9 |
| ub4 | 20 | 3.7 | 3.4 |
| hb4 | 20 | 10.0 | 3.2 |
| ub2 | 14 | 7.6 | 3.2 |
| ub3 | 18 | 5.5 | 3.0 |
| ub8 | 10 | 4.4 | 2.9 |
| ub7 | 11 | 5.3 | 2.8 |
| hb2 | 12 | 7.3 | 2.6 |
| hb3 | 9 | 5.3 | 2.5 |
| ub5 | 12 | 14.1 | 2.4 |
| hb1 | 13 | 6.8 | 2.3 |
| **mean** | **15.9** | **7.3** | **3.0** |
| **std. dev.** | **5.7** | **3.0** | **0.5** |
| **Short grass sites** | | | |
| ul6 | 36 | 10.3 | 4.6 |
| ul5 | 34 | 6.3 | 4.5 |
| ul8 | 40 | 16.5 | 4.3 |
| ul4 | 31 | 9.2 | 4.2 |
| hl1 | 25 | 7.0 | 4.1 |
| ul7 | 26 | 8.8 | 3.9 |
| hl4 | 27 | 7.5 | 3.9 |
| ul3 | 33 | 8.3 | 3.8 |
| ul2 | 29 | 12.0 | 3.7 |
| ul1 | 20 | 8.4 | 3.7 |
| hl3 | 19 | 6.9 | 3.2 |
| hl2 | 19 | 6.6 | 2.7 |
| **mean** | **28.3** | **9.0** | **3.9** |
| **std. dev.** | **6.6** | **2.8** | **0.5** |

**Table 3.3:** *Results of analyses of variance comparing the species richness, species diversity (H') and density of birds in the short and tall grasslands*

| | Df | Mean squares | F Ratio | Prob>F | |
|---|---|---|---|---|---|
| **Species number** | 1 | 912.66 | 22.03 | 0.0001 | *** |
| Error | 22 | 41.41 | | | |
| **Species Diversity** | 1 | 4.56 | 15.43 | 0.0007 | *** |
| Error | 22 | 0.29 | | | |
| **Density** | 1 | 16.65 | 1.85 | 0.1874 | |
| Error | 22 | 8.99 | | | |

** P < 0.05 ** P < 0.01 *** P < 0.001*

True habitat specialists were identified by comparing presence /absence data from the point count surveys (Appendix 3.3) with those found in the grasslands and testing for statistical significance of habitat occurrences with Fisher's Exact Test. Only the top 35 numerically dominant species listed in Appendix 3.3 were tested. The analysis revealed that birds present in both the short and tall grass swards were mainly itinerant species, but there were three short grass specialists, seven tall grass specialists and two grassland specialists that made use of both short and tall grass areas (Table 3.4).

**Table 3.4.** *A list of the most numerically dominant bird species found in the grassland sites indicating of the proportion of sightings of these species in short grass areas, tall grass areas and in other habitats. Grassland specialists are highlighted (Fisher's exact test)*, the number of sightings (n) is also given.

| Species | Habitats | | | n | Fisher's exact p | |
|---|---|---|---|---|---|---|
| | Short Grass | Tall Grass | Other | | | |
| Helmeted Guineafowl | | 40 | 60 | 15 | 0.157 | |
| **Small Buttonquail** | | **95** | **5** | **20** | **0.002** | ** |
| Black-bellied Bustard | | 44 | 56 | 16 | 0.119 | |
| **Crowned Lapwing** | **83** | | **17** | **28** | **0.007** | ** |
| Cape Turtle Dove | 56 | | 44 | 68 | 0.242 | |
| Red-faced Mousebird | | 31 | 69 | 29 | 0.596 | |
| Flappet Lark | | 46 | 54 | 11 | 0.289 | |
| **Rufous-naped Lark** | **40** | **47** | **13** | **27** | **0.004** | ** |
| **Sabota Lark** | **89** | | **11** | **33** | **0.001** | *** |
| Fork-tailed Drongo | 76 | | 24 | 43 | 0.342 | |
| Dark-capped Bulbul | 63 | | 37 | 48 | 0.325 | |
| **African Stonechat** | | **97** | **3** | **50** | **0.001** | *** |
| **Zitting Cisticola** | | **77** | **23** | **24** | **0.013** | * |
| Rattling Cisticola | 1 | 56 | 44 | 56 | 0.109 | |
| **Croaking Cisticola** | | **83** | **17** | **14** | **0.049** | * |
| Southern Black Flycatcher | 79 | | 21 | 28 | 0.289 | |
| Pale Flycatcher | 84 | | 16 | 38 | 0.260 | |
| Chin-spot Batis | | 57 | 43 | 32 | 0.346 | |
| **African Pipit** | **98** | | **2** | **40** | **0.000** | *** |
| **Yellow-throated longclaw** | **38** | **43** | **19** | **27** | **0.050** | * |
| Common Fiscal | 77 | | 23 | 36 | 0.255 | |
| Red-backed Shrike | 67 | | 33 | 37 | 0.256 | |
| Cape Glossy Starling | 76 | | 24 | 73 | 0.237 | |
| Violet-backed Starling | 36 | | 74 | 23 | 0.184 | |
| Southern Grey-headed Sparrow | 76 | | 24 | 30 | 0.119 | |
| Yellow-throated Petronia | 35 | | 65 | 49 | 0.705 | |
| Red-billed Quelea | 63 | | 37 | 22 | 0.315 | |
| **Fan-tailed Widowbird** | | **84** | **16** | **13** | **0.050** | * |
| **White-winged Widowbird** | | **88** | **12** | **11** | **0.050** | * |
| **Red-collared Widowbird** | | **83** | **17** | **17** | **0.050** | * |
| Pin-tailed Whydah | | 60 | 40 | 15 | 0.410 | |
| Blue Waxbill | 64 | | 36 | 42 | 0.345 | |
| Yellow-fronted Canary | 30 | | 70 | 44 | 0.299 | |
| Golden-breasted Bunting | 28 | | 72 | 35 | 0.063 | |

* P < 0.05 ** P< 0.01 *** P < 0.001

**Ordination of bird data**

Bird abundance data of all individuals observed at each of the study sites, commonly referred to as the 'grassland birds' in this study, were ordinated on a site-by-site basis to detect similarities and/or differences between bird communities. A gradient of decreasing grass height is evident from left to right in the DCA ordination diagram (Figure 3.6), with tall grass areas clustering on the left hand side and short grass areas on the right, indicating that the two extremes of the grassland continuum support distinctly different bird communities. The high eigenvalues (Axis 1 = 0.677, Axis 2 = 0.214) indicate that these patterns are well supported. There is also a high turnover of bird species along the gradient of increasing grass height, i.e. high ß-diversity. This is highlighted in Figures 37 and Figure 3.8, which show how a suite of bird species is present when the grass is short (1-4 DPM units), and are then replaced by another suite of species when the grass height reaches 6 DPM units. .

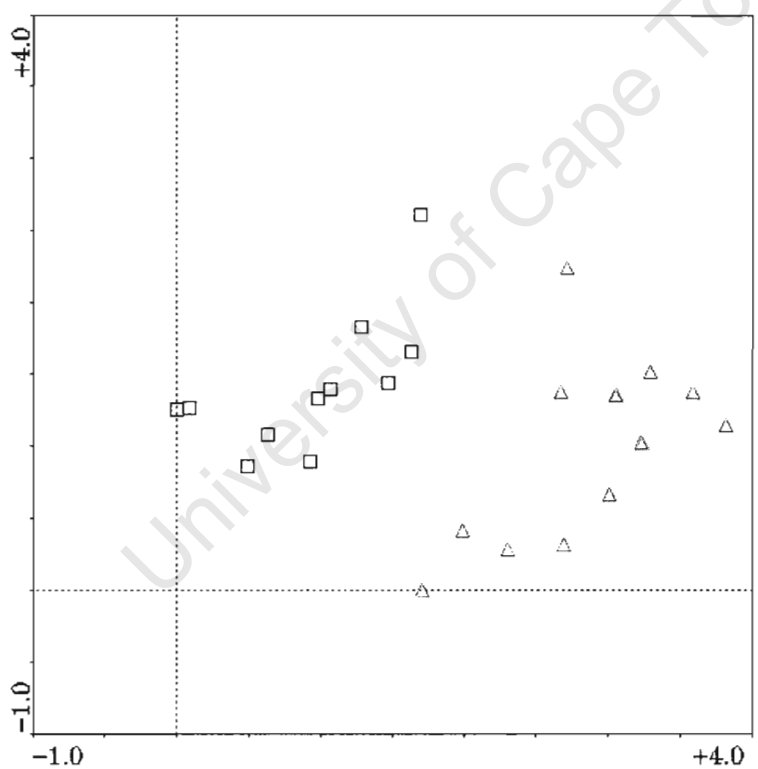




**Figure 3.6***: Detrended correspondence analysis (DCA) ordination of the first two axes of grassland bird species and density data. The triangles represent sites with short grass swards and squares sites with tall grass swards.*

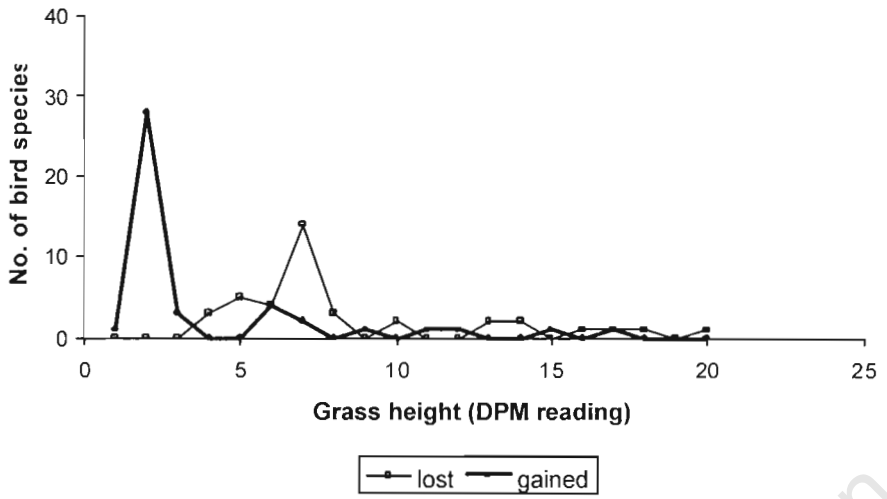


**Figure 3.7:** *The number of bird species lost and gained along a gradient of increasing grass height (DPM readings)*



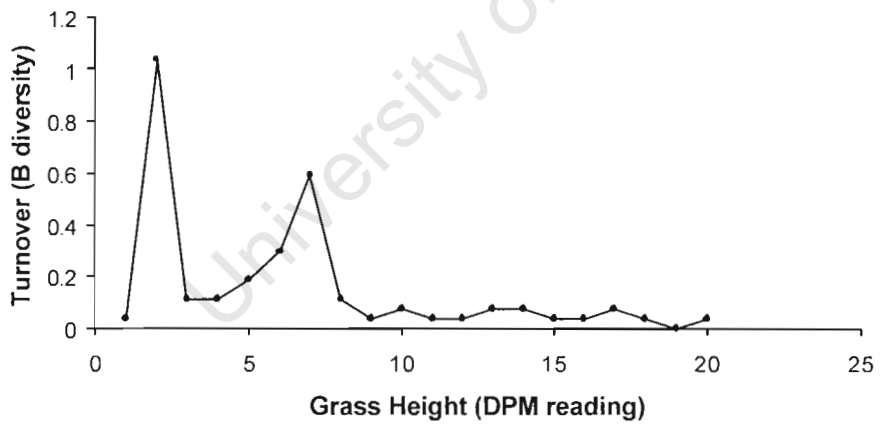


**Figure 3.8:** *Turnover in bird species along a gradient of increasing grass height (DPM readings).*

**Ordination of bird data and habitat variables**

The environmental variables, including two plant species variables and 12 structural variables (Appendix 3.1), were used in the DCCA to relate bird incidence and abundance to vegetation characteristics (Figure 3.7). The eigenvectors derived from axis 1 and axis 2 of a DCA of plant species composition data (ordination not shown) were used as the plant species variables. All habitat variables displayed in Appendix 3.1 were used as the structural variables. The DCCA ordination scattered tall grass bird specialists on the left while short grass specialists are distributed on the right hand side of the diagram. Grassland specialists that make use of both short and tall grass areas clustered in the middle, along with other generalist species.

Environmental variables are represented as arrows on the ordination diagram. The relative length and direction of the arrows are important as they indicate relative strengths and the direction of the gradients. Several of the environmental variables in this ordination indicated similar gradients. Thus, to simplify the diagram, only the variable with the greatest correlation in a particular direction was displayed (Figure 3.9). Grass height had the highest correlation, with the location of bird assemblages along the ordination axes whereas grass species composition produced the lowest correlation (Table 3.5). This suggests that habitat structure i.e. grass height, is having the greatest influence on bird species composition. The DCCA produced eigenvalues of 0.638 and 0.028 for the first and second axes, and explained 73.6 percentage of the variance in the relationship between bird species and the environment variables.

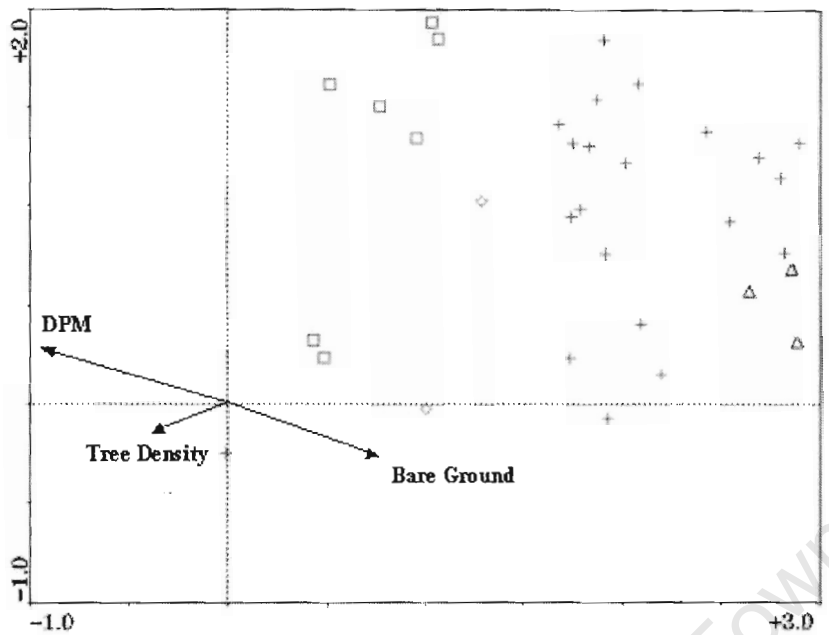


**Figure 3.9**: *Detrended Canonical Correspondence Analysis (DCCA) ordination of the first two axis of the incidence and abundance of bird and environmental variables. The triangles represent short grass bird specialists, squares tall grass specialists, diamonds grassland specialists that make use of both tall and short grass swards and the plus signs represent generalist species. The arrows indicate the gradient of the grass height (DPM), tree density and percentage bare ground.*

**Table 3.5:** *Scores for environmental variables on the first 2 axes of a DCCA*

| Environmental variables | Axis 1 | Axis 2 |
|---|---|---|
| **Grass height gradient** | | |
| DPM | -0.892 + | -2.522 |
| 0 FHP | -0.770 | -1.547 |
| 0.5 FHP | 0.759 | 3.768 |
| 0.25 FHP | -0.608 | -0.708 |
| 0.75 FHP | 0.471 | -0.300 |
| 1 FHP | 0.217 | -0.060 |
| 1.5 FHP | -0.237 | 0.151 |
| Plant species Axis 1 | -0.125 | -1.435 |
| Plant species Axis 2 | 0.000 | 0.000 |
| GC3 | 0.000 | 0.000 |
| **Bare ground gradient** | | |
| Bare Ground | 0.265 + | -0.510 |
| GC2 | 0.166 | -0.277 |
| GC1 | -0.145 | -1.445 |
| **Tree gradient** | | |
| Tree Density | 0.194 + | 0.349 |

+ displayed in biplot ordination



A generalised linear model was used to test the relative importance of grass structure, grass species composition and tree densities on bird incidence and abundance. The natural logarithms of DPM readings were used as an index of grass structure. The total number of lawn grass (stoloniferous) species present versus the total number of bunch grass (caespitose) species present at each site, was used to categorise each site as either a lawn or bunch grass class, to provide nominal data on grass species composition, along with data on tree densities. The scores of axis 1 and 2 from DCA of average bird densities at each site were utilised as the response variable. The model explained 90 percent of the variation of the three independent variables. Results from the 1st axis revealed that bird abundances were not related to grass species or to the trees, but were related to the physical structure of grasslands, as it showed a highly significant ($P<0.0001$) relationship with the natural logarithm of grass height (Table 3.6). The second axis showed no significant relationships (Table 3.6).

**Table 3.6:** *Results of a generalised linear model using bird assemblage as the response variable (DCA axis 1 and axis 2) and grass composition (Grass Class), grass biomass (Log DPM) and tree density as the independent variables.*

| Factors | Sum of Squares | F Ratio | Prob>F |
|---|---|---|---|
| **Response: DCA Axis 1 scores** | | | |
| Grass Class | 0.1003 | 0.6016 | 0.4470 |
| Log DPM | 7.7414 | 46.4077 | <.0001 |
| Tree density | 0.3173 | 1.9026 | 0.1830 |
| **Response: DCA Axis 2 scores** | | | |
| Grass Class | 0.1952 | 0.5301 | 0.4750 |
| Log DPM | 0.0001 | 0.0003 | 0.9868 |
| Tree density | 0.4985 | 1.3535 | 0.2584 |



## *Discussion*

There was considerable bird species turnover along the gradient from short grass areas to tall grass areas, with each extreme of the continuum supporting a distinct avifaunal community. A total of 88 birds species were identified within the grasslands, with short grass areas supporting 74 and tall grasslands 59 (Appendix 3.2). Short grass areas had a significantly higher species richness and diversity than tall grass areas. Of the grassland specialists identified, seven inhabited tall grass areas, three inhabited short grass areas, with two utilised both tall and short grass areas. Many itinerant species made use of the grasslands. This was particularly evident in the short grass areas, suggesting that these short grass areas provide valuable food resources for a large suite of species.

There was a significant link between grassland bird distribution and vegetation structure, with grass height having the greatest influence, but little association with floral composition. Structure is therefore the main driving force of grassland bird distribution in HiP.

Although short grass birds were found on both grazing patches and grazing lawns, grazing lawns may be of more value, because they represent a more stable form of short grass, persisting for longer periods and being less likely to revert to tall bunch grassland. In the chapters that follows I will to test if post-burn bunch grasslands (inside HiP), which are short in the early post-burn recovery stage and therefore structurally resemble lawns, or the heavily grazed communally farmed areas outside the park support similar birds to those found on the short grass areas inside the park. If this is the case, then fire, or areas outside the park, would provide an alternate habitat to grazing lawns within the park. If they do not support the short grass specialists, then the grazing lawn habitat in HiP would be important for the conservation of these birds on a regional scale.

The findings of this chapter suggest that grassland bird communities would be particularly sensitive to changes in vegetation structure, and therefore vegetation management could have a direct effect on bird assemblages. For example Archibald *et al.* (2005) has shown how frequent burning, of fire intervals of less than four years inhibits the development of grazing lawns in HiP. After a fire event, herbivores are attracted to the post-burn flush of new growth and consequently drawn off heavily grazed patches. Very small fires may concentrate grazers which might initiate a grazing patch but the normal large fires will pull grazers off grazing patches and cause the herbivores to spread out on the large burnt areas and thus have a less concentrating effect. In the long term, frequent large fires will indirectly reduce the density and diversity of large mammals species on grazing patches, and reduce lawn grass formation because grazers would not persist in a grazing patch long enough to cause a compositional shift from tall grass to lawn grass species. Consequently birds that require grazing lawns would be lost and those requiring tall bunch grasslands would benefit. However the use of post burn habitats still needs to be investigated (see next chapter), as it may well provide a vital habitat for short grass birds, in which case frequent fire may be beneficial.

Reductions in large herbivore numbers, in particular white rhino that are key in maintaining grazing lawns (Zululand Grass Project, unpublished, MS Waldram, pers. comm.) could also result in the reduction of grazing lawns. This will once again benefit species requiring tall grass and adversely affect those requiring short grass.

In summary, direct and indirect effects of the management of fire and large herbivores can have a direct and/or indirect effect on habitat for other species. The results of this chapter show that changes in the grassland sward, readily influenced by such management, are likely to influence bird assemblages in the park. Both tall and short grassland types are utilised by habitat specialists, and these species would be directly affected by changes in the extent of the different grassland types.

**Appendix 3.1:** *Means of habitat variables at each grassland site*

| Sites | DPM | BG | GC1 | GC2 | GC3 | Tree Den | 0FHP | 0.25 FHP | 0.5FHP | 0.75FHP | 1FHP | 1.5FHP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| hb1 | 10.3±5.8 | 3±1.2 | 0.4±0.2 | 20.4±4.7 | 76.1±5.2 | 15.2 | 1.7 | 0.7 | 0.3 | 0.1 | 0.1 | 0.0 |
| hb2 | 11.9±5.1 | 0.1±0.1 | 0.1±0.1 | 8.0±2.7 | 91.7±2.8 | 18.0 | 1.9 | 1.0 | 0.5 | 0.1 | 0.0 | 0.0 |
| hb3 | 13.7±9.5 | 0.5±0.6 | 0.0±0.0 | 14.1±3.2 | 85.3±3.2 | 19.0 | 2.0 | 0.9 | 0.5 | 0.2 | 0.0 | 0.0 |
| hb4 | 9.8±4.9 | 3.2±0.7 | 1.5±0.5 | 26.5±1.7 | 68.6±2.0 | 30.2 | 1.8 | 0.4 | 0.1 | 0.1 | 0.0 | 0.0 |
| hl1 | 4.0±2.6 | 18±4.0 | 53.5±4.7 | 18.1±4.6 | 10.4±1.8 | 23.7 | 0.3 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| hl2 | 3.9±2.3 | 10.1±2.9 | 63.2±6.6 | 20.3±6.5 | 6.3±1.3 | 17.6 | 0.3 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 |
| hl3 | 6.4±4.1 | 9.6±3.6 | 48.3±9.5 | 33.2±9.1 | 8.7±4.8 | 16.9 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| hl4 | 3.1±2.4 | 14.5±3.0 | 68.4±2.8 | 13.5±1.6 | 3.4±1.0 | 17.4 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 |
| ub1 | 9.3±6.5 | 9.2±4.9 | 9.2±9.2 | 24.0±9.4 | 57.5±17.7 | 11.6 | 3.8 | 2.8 | 2.1 | 0.7 | 0.2 | 0.0 |
| ub2 | 9.1±5.5 | 1.8±0.5 | 9.5±0.4 | 18.5±3.3 | 70±5.5 | 57.3 | 2.8 | 1.2 | 0.6 | 0.3 | 0.2 | 0.0 |
| ub3 | 12.4±9.2 | 1.7±0.9 | 1.1±0.7 | 25.7±9.5 | 71.3±10.4 | 45.2 | 2.0 | 0.8 | 0.4 | 0.2 | 0.1 | 0.0 |
| ub4 | 7.0±3.5 | 7.3±4.0 | 10.1±8.9 | 33.8±9.9 | 48.6±18.2 | 18.3 | 1.6 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| ub5 | 9.0±4.6 | 0.6±0.5 | 1.0±0.8 | 13.6±5.3 | 84.6±6.0 | 21.3 | 3.1 | 1.5 | 0.8 | 0.4 | 0.1 | 0.0 |
| ub6 | 5.8±2.5 | 12.8±7.2 | 23.0±9.7 | 30.5±9.0 | 33.5±12.3 | 18.4 | 1.9 | 0.6 | 0.3 | 0.2 | 0.1 | 0.0 |
| ub7 | 10.2±5.1 | 0.7±0.4 | 2.1±1.3 | 23.1±6.7 | 74.0±7.6 | 8.8 | 1.0 | 0.5 | 0.2 | 0.1 | 0.1 | 0.0 |
| ub8 | 8.7±4.7 | 1.0±0.6 | 2.0±0.9 | 27.5±9.9 | 69.4±11.3 | 24.2 | 1.7 | 0.5 | 0.3 | 0.2 | 0.1 | 0.0 |
| ul1 | 2.4±1.3 | 24.4±5.6 | 58.5±5.8 | 10.9±5.0 | 6.0±5.3 | 20.9 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| ul2 | 3.4±1.6 | 12.4±3.6 | 59.4±8.7 | 28.1±9.1 | 0.0±0.0 | 19.5 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| ul3 | 3.6±3.4 | 13.2±4.6 | 71.1±6.7 | 15.0±8.0 | 0.6±0.7 | 15.8 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| ul4 | 2.7±2.4 | 30.8±6.3 | 57.8±2.9 | 11.1±4.8 | 0.1±0.1 | 17.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 |
| ul5 | 3.2±1.7 | 7.3±10.3 | 62.0±3.6 | 30.6±9.3 | 0.0±0.4 | 22.8 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| ul6 | 2.5±1.4 | 42.5±8.4 | 47.8±4.5 | 9.4±5.2 | 0.1±0.1 | 25.8 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| ul7 | 3.8±2.0 | 11.8±4.4 | 52.8±10.2 | 35.1±14.2 | 0.1±0.1 | 29.8 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| ul8 | 3.4±1.3 | 26.6±8.7 | 52.1±4.2 | 19.4±9.2 | 1.7±1.3 | 18.4 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |

DPM = index of grass biomass; BG = percentage bare ground; GC1 = amount of short grass; GC2 = amount of tall grass; GC3 = amount of tall grass; Tree den = relative tree density. FHP0 = Foliage height profile value at 0 m; FHP0.25= Foliage height profile value at 0.25 m; FHP0.5= Foliage height profile value at 0.5 m; FHP0.75= Foliage height profile value at 0.75 m; FHP1= Foliage height profile value at 1 m; FHP1.5= Foliage height profile value at 1.5 m and ± = standard error

**Appendix 3.2** *Mean bird densities per km$^2$ at grassland sites.*

| Common name | hb1 | hb2 | hb3 | hb4 | hl1 | hl2 | hl3 | hl4 | ub1 | ub2 | ub3 | ub4 | ub5 | ub6 | ub7 | ub8 | ul1 | ul2 | ul3 | ul4 | ul5 | ul6 | ul7 | ul8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acacia Pied Barbet | | | | | | | | | | | 0 | | | 5 | | 12 | | | 4 | | 4 | | 15 | 7 |
| African Hoopoe | | | | 4 | 4 | 6 | 4 | 14 | | | | | 7 | | | | | | 2 | 3 | 16 | 19 | 5 | 31 |
| African Pipit | | | | 12 | | 243 | 150 | 58 | | | | | | | | | | 211 | 230 | 150 | 28 | | | 28 |
| African Stonechat | | 66 | 45 | 31 | | | | | | | | | | | | | | | | | | | | |
| Bald Ibis | | | | | | | | | | | | | | | | | | | 16 | | | | | |
| Black Cuckooshrike | 8 | | | | | | | | | | | | | | | | 5 | | | | | | | 2 |
| Black-backed Puffback | | | | | | | | | | | | | | | | | | | | | | 1 | | |
| Black-bellied Bustard | | 5 | | 4 | | | | 1 | | 47 | | | | 5 | | | | | 1 | | | | | |
| Black-collared Barbet | | | | | | | | 1 | | | | | | | | | | | | | | | | |
| Black-crowned Tchagra | | | | | 16 | | | 6 | | 9 | | | | 5 | | 12 | | 6 | | | | | 10 | |
| Black-headed Oriole | | | | | | | | | | | | | | | | | 4 | | | | | | | |
| Blue Waxbill | | | | | | | | 91 | | | 8 | | | | 40 | | | 244 | 42 | 93 | | 41 | 218 | 133 |
| Brubru | | | | | | | | | | 2 | 1 | 2 | | | | 12 | 4 | | | 6 | 2 | 7 | | 6 |
| Burchell's Coucal | | | | 4 | 3 | | | | | | | | | | | | | | | | | | | |
| Cape Glossy Starling | | | | 16 | 62 | 53 | 13 | 20 | 17 | | | 5 | | | | 36 | 11 | 15 | 17 | 35 | 33 | 68 | 45 | 83 |
| Cape Turtle Dove | | | | 8 | 9 | 15 | 16 | 40 | | | 10 | 15 | | 21 | | | 124 | 74 | 60 | 40 | 20 | 53 | 27 | 110 |
| Cardinal Woodpecker | | | | | | | | | | | | | | | | | | | | | 2 | | | |
| Chin-spot Batis | | | | | | | | 8 | | 9 | | | 14 | | 26 | | 15 | 15 | 3 | 11 | 3 | 8 | | 8 |
| Common Fiscal | | | | 16 | | 16 | 18 | | | | | 35 | 14 | 15 | | | 62 | 6 | 3 | 2 | | | 11 | 3 |
| Common Scimitarbill | | | | | | | | | | | | | | | | | | | | | 2 | 5 | | 8 |
| Common Waxbill | | | | | | | | | | | | | 7 | | | | | | | | | | | |
| Corn Crake | 8 | | | | | | | | | | | | | | | | | | | | | | | |
| Crested Barbet | | | | | | 1 | | | | | | | | | | | 6 | | | | | 2 | | 8 |
| Croaking Cisticola | 142 | 280 | 203 | 86 | | | 6 | 3 | 127 | 122 | 85 | 5 | 229 | 5 | 172 | 60 | | | | | | | | |
| Crowned Lapwing | | | | | | 106 | 120 | | | | | | | 10 | | | | 21 | 51 | | | | | 10 |
| Dark-capped Bulbul | 8 | 22 | | 19 | 31 | | 25 | 58 | 12 | 19 | 5 | 5 | | 10 | 13 | | 62 | 11 | | 10 | | 15 | 44 | |
| Emerald-spotted Dove | | | | | 18 | | 5 | 7 | 6 | | | | | | | | 7 | | | | 13 | 4 | 6 | 8 |
| European Roller | | | | | | | | | | | 15 | | | | | | | | | 1 | | | | |
| Fan-tailed Widowbird | 16 | 82 | 45 | 19 | | 2 | 9 | | | | 45 | | 201 | 15 | | | | | 5 | | | | | |
| Fiscal Flycatcher | | | | | | | | | | | | | | | | | | 13 | | | | 37 | 5 | |
| Flappet Lark | | | 15 | | | | | | 35 | | | | | | | | | | | | | | | |
| Fork-tailed Drongo | | 5 | | | 39 | | 10 | 22 | 6 | | | 25 | | 5 | | | 6 | 20 | 2 | 22 | 17 | 25 | | 16 |
| Golden-breasted Bunting | | | | | 25 | 2 | 3 | 20 | 35 | | | 20 | 7 | | | | 16 | 4 | 3 | 12 | 21 | 13 | 38 | 11 |
| Golden-tailed Woodpecker | | | | | | | | | | | | | | | | | | | | | | | | 1 |
| Greater Honeyguide | | | | | | | | | 6 | | | | | | | | | | | | | | | |
| Green Wood-hoopoe | | | | | | | | | | | | | | | | | | | | | 3 | 4 | | 15 |
| Grey Penduline Tit | | | | | | | | | | | | | | | | | | | | | | | | 7 |
| Hadeda Ibis | | | | | 7 | 3 | | 8 | | | | 5 | | 3 | | | 28 | 3 | | 14 | 11 | 15 | | 6 |
| Helmeted Guineafowl | | | | | | | | | | | | | | 57 | | | | | 8 | | | | | |
| Jacobin Cuckoo | | | | | | | | | | | | 5 | | | | | | | | | | | | |
| Kurrichane Thrush | | | | | | | | | | | | | | | | | | | | | 11 | 11 | 24 | 25 |
| Lazy Cisticola | | | | | | | | | 6 | | | | | | | | | | | | | | | |
| Lilacbreasted Roller | | | | | | | | | | | | | | | | | | | | | 1 | | | 2 |

**Appendix 3.2 cont.**: *Mean bird densities per km$^2$ at grassland sites*

| Common name | hb1 | hb2 | hb3 | hb4 | hl1 | hl2 | hl3 | hl4 | ub1 | ub2 | ub3 | ub4 | ub5 | ub6 | ub7 | ub8 | ul1 | ul2 | ul3 | ul4 | ul5 | ul6 | ul7 | ul8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Bee-eater | 8 | | | 19 | 33 | | | | | | | 5 | | | | | | 65 | | | | | | |
| Longbilled Crombec | | | | | | | | | 6 | | 5 | | | | | | | | | 8 | 19 | 9 | | |
| Long-tailed Paradise Whydah | | | | | | | | | | | | | | | | | | | 4 | | | | | 8 |
| Marico Sunbird | | | | | | | | | 35 | | | | | | | | | | | | | | 6 | |
| Masked Weaver | | | | | 6 | | | | | | | | | | | | | 10 | 7 | | 4 | 5 | | |
| Melba Finch | | | | | | | | | | | | | | | | | | | | | | | 25 | 11 |
| Orange-Breasted Bush shrike | | | | | | | | | | | 5 | 1 | | | | | | | | | | | | |
| Pale Flycatcher | | | | | 10 | | | 19 | 6 | | 10 | | | 5 | | | | | 6 | 26 | 35 | 72 | 12 | 73 |
| Paradise Flycatcher | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| Pin-tailed Whydah | | 5 | 8 | 8 | 3 | 1 | | 4 | 6 | 9 | | | | 21 | | | | | | | | | | |
| Plain-backed Pipit | | | | | | | | | 12 | | | | | | | | | | | | | | | |
| Rattling Cisticola | 8 | | | 12 | 92 | | | 42 | 58 | 75 | 45 | 35 | 7 | | 79 | 133 | | 7 | 2 | 26 | 18 | 18 | 21 | 12 |
| Red-backed Shrike | | | | | 5 | 2 | | 29 | 40 | | | 5 | | 36 | 13 | 36 | 51 | 33 | 30 | 36 | 39 | 73 | 64 | 36 |
| Red-billed Quelea | | | | | | | | | 69 | | | | | | | | 72 | 36 | | 72 | 55 | 80 | | 282 |
| Red-collared Widowbird | | 60 | 38 | 32 | | | | | 173 | | | | | 15 | | | | | 34 | | | | | |
| Red-faced Mousebird | | | | | | | | 23 | 6 | | 20 | 5 | | | | | 94 | 36 | | 47 | 18 | 65 | 56 | 42 |
| Red-throated Wryneck | | | | | | 2 | | | | | | | | | | | | | | 6 | | | | 12 |
| Rufous-naped Lark | 8 | 11 | | 66 | 11 | 39 | 27 | | | 56 | 5 | | 97 | 62 | | | | 7 | 21 | 9 | | | | |
| Sabota Lark | | | | | | | | | | | | | | 31 | | | | 70 | 10 | 46 | 53 | 61 | 7 | 144 |
| Scarlet-chested Sunbird | | | | | | | | | 29 | | | | | | | | | | | | | 2 | 3 | |
| Secretarybird | | | | | | 3 | 2 | | | | | | | | | | | | 4 | 3 | | | | |
| Small Buttonquail | 16 | | 8 | 27 | | | | | | | | | | 67 | | | | | | | | | | |
| Southern Black Flycatcher | | | | | 36 | | | 7 | | | 5 | | | | 13 | 36 | | | | 14 | 8 | 20 | 34 | 40 |
| Southern Black Tit | | | | | 10 | | | | 17 | | | 5 | | 10 | 13 | | | 8 | 3 | | 6 | 22 | | |
| Southern Grey-headed Sparrow | | | | | 34 | | 20 | 5 | | | | | | | | | | 5 | 40 | | 37 | 6 | | 53 |
| Southern Ground-hornbill | | | | | | | | | | | | | | | | | | | 2 | | | | | |
| Southern Yellow-billed hornbill | | | | | | | | | | | | | | | | | | | | | 4 | | | 16 |
| Speckled Mousebird | 8 | | | | | | | | | | | 5 | | | | | | | | | | | | |
| Striped Kingfisher | | | | | 22 | | | | 0 | | | | | | | | | | | 17 | 13 | 19 | | 12 |
| Tawny-flanked Prinia | | 16 | | | | | | | | | | | | | | | | | | | | | | |
| Three-banded Plover | | | | | | 1 | | | | | | | | | | | | | | | | | | |
| Three-streaked Tchagra | | | | | | | | | | | | | 7 | 5 | | | | | | | | | | |
| Village Weaver | | | | | 6 | 5 | | 5 | | | | | | | | | | 5 | 7 | 5 | | 10 | 18 | 10 |
| Violet-backed Starling | | | | | 60 | | | 4 | 6 | 19 | | | | | | | 8 | | 6 | | 12 | 4 | | 28 |
| White-bellied Sunbird | | | | | | | 2 | 2 | | | | | | | | | | | | | | | | |
| White-browed Scrub-robin | | | | | | | | | | | | | | | | | | | | | | 24 | | |
| White-fronted Bee-eater | | | | | | | | | | | | | | | | | | | | 3 | 20 | 7 | 10 | 18 |
| White-winged Widowbird | 7 | | | | | | | | 169 | | 5 | | | 10 | | | | 13 | | | | | | |
| Woolly-necked Stork | | | | | | | | | | | | | | | | | | | 7 | | | | | |
| Yellow-bellied Eremomela | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| Yellow-fronted Canary | | | | 31 | 23 | | 26 | 142 | 12 | 66 | | 5 | | | 26 | | 36 | 27 | 47 | 18 | 7 | 30 | 19 | 26 |
| Yellow-throated Longclaw | 79 | 55 | 68 | 167 | | 42 | 21 | | 58 | 84 | 25 | 69 | 111 | 5 | | 36 | 24 | | | 4 | | | 13 | |
| Yellow-throated Petronia | | | | | 49 | | | | | 1 | | | | 22 | 13 | | 97 | 10 | 18 | 39 | 11 | 38 | 26 | 83 |
| Zitting Cisticola | 276 | 22 | 30 | 295 | | 31 | 119 | 18 | 58 | 141 | 181 | 69 | 528 | 82 | 53 | 12 | | 70 | 24 | 19 | | | | |

h = Hluhluwe, u = iMfolozi, b = tall grass, l = short grass

**Appendix 3.3:** *Presence absence data of birds in thickets (T), low density woodland (L), medium density woodland and (M) and high density (H).*

| Common name | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 | L1 | L2 | L3 | L4 | L5 | L6 | L7 | L8 | L9 | L10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acaica Pied Barbet | | | | | | | | | | | | | | 1 | | | | | | |
| African Hoopoe | | | | | | | | | | | 1 | | | | 1 | | | | | 1 |
| African Paradise Flycatcher | | | | | | | | | | | | | | | | | | | | |
| Black-backed Puffback | | | | | | | | | | | | 1 | | | | | | 1 | | |
| Black-bellied Bustard | | 1 | | | 1 | | 1 | | | 1 | | | | | | | | | | |
| Black-collared Barbet | | | | | | | | | | | | 1 | | 1 | | 1 | 1 | | | |
| Blue Waxbill | 1 | | 1 | | 1 | | 1 | | | | | | | | | 1 | | 1 | 1 | 1 |
| Brown-crowned Tchagra | | | | | | | | | | | | | | | 1 | | | | | |
| Brown-hooded Kingfisher | | | | | | | | | | | | 1 | | | | 1 | | 1 | | |
| Brubru | | | | | | | | | | | | 1 | | 1 | | | | | 1 | |
| Buhveld Pipit | | | | | | | | | | | | | | | | | | | | |
| Burcell's Coucal | | | 1 | | | | | | 1 | | 1 | | 1 | | | | | | | |
| Cape Glossy Starling | 1 | | 1 | 1 | | 1 | | 1 | 1 | | | 1 | | | | | | 1 | | 1 |
| Cape Turtle Dove | | 1 | | | 1 | | | | | 1 | | 1 | | 1 | | | | | | 1 |
| Cape White-eye | | | 1 | | 1 | | | | | | | | | | | | | | | |
| Chinspot Batis | | | | | | | | | | | 1 | | | | 1 | | 1 | | | |
| Commmon Fiscal | | | | | | | | | | | | | | | | 1 | | 1 | 1 | |
| Common Scimitarbill | | | | | | | | | | | | 1 | | | | | | | 1 | |
| Common Waxbill | | | | | | | | | | | | | | | | | | | | |
| Crested Barbet | | | | 1 | | 1 | | | | 1 | | | | 1 | | | | | | 1 |
| Crested Francolin | | | 1 | | 1 | | 1 | | | | | | | | | | | | | |
| Dark-capped Bulbul | | 1 | | 1 | 1 | 1 | | | | | | 1 | | | | 1 | | | 1 | |
| Eastern Nicator | | 1 | | | | | | | | | | | | | | | | | | |
| Emerald-spotted Dove | | | | | | 1 | | | | | | | | | | | | | | |
| European Roller | | | | | | | | | | | | | | | | 1 | | | 1 | |
| Fork-tailed Drongo | | | 1 | | 1 | | 1 | | | | | | | | | 1 | | | | |
| Golden-breatsed Bunting | | | | | | | | | | | | | | 1 | | | | | | 1 |
| Golden-tailed Woodpecker | | | | | | | | | | | | | 1 | | | | 1 | | | |
| Greater Honeyguide | | | | | | | | | | | | | | | | | | | | |
| Green Wood-Hoopoe | | | | | | | | | | | | | | | | | | | | |
| Green-back Camaroptera | | | | | 1 | | | | | | | | | | | | | | | |
| Grey-headed Bush Shrike | | 1 | | | | | | | | | | | | | | | | | | |
| Hadeda Ibis | | | 1 | | | | | | | | | | | | | | | | | |
| Helmeted Guineafowl | | | 1 | | | 1 | | 1 | | | | | | | | 1 | | | | |
| Klaas's Cuckoo | | | | | | | | | | | | | | | | | 1 | | | |
| Lilac-breasted Roller | | | | | | | | | | | | | | | | | | | | 1 |
| Little Bee-eater | 1 | 1 | | | | 1 | | | | | | | | | | | | | | |
| Long-billed Crombec | | | | | | | | | | | 1 | | | | | | 1 | | 1 | |
| Magpie Shrike | | | | | | | | | | | | | | | | | 1 | | | |
| Natal Francolin | | | | | 1 | | | | | | | | 1 | | | | | | 1 | |
| Purple-crested Turacc | | | | 1 | | | | | | | | | | | | | | | | |
| Rattling Cisticola | | 1 | 1 | | 1 | 1 | 1 | | | 1 | | 1 | | | 1 | | 1 | | 1 | |
| Red-backed Shrike | | | | 1 | | | 1 | | 1 | | 1 | | 1 | | | 1 | | 1 | | |
| Red-billed Firefinch | | | | | | | | | | | | | | | | | | | | |
| Red-billed Quelea | | | | | | | | | | | | 1 | | | | | | 1 | | |
| Red-faced Mousebird | | | | | | | | | | | | | | | 1 | | | | | |
| Red-fronted Tinkerbird | | | | | | | | | 1 | | | | | | | | | | | |
| Red-thorated Wryneck | | | | | | | | | | | | | | | 1 | | | 1 | | |
| Rudd's Apalis | | | | | | | | | | | | | | | | 1 | | | | |
| Scarlet-chested Sunbird | | | | | | | | | | | | | | | | | | | | |
| Sombre Greenbul | | | | 1 | | 1 | | | | | | | | | | | | | | |
| Southern Bald Ibis | | | | | | | | | | | 1 | | | | | | | | | |
| Southern Black Tit | | | | | | | | 1 | | 1 | | | | 1 | | 1 | | | | |
| Southern Boubou | | | | 1 | 1 | | | | | | | | | | | | | | | |
| Southern Yellow-billed Hornbill | | | | | | | | | | | | | | 1 | | | | | | |
| Speckled Mousebird | | | | | 1 | | | | | | | | | | | | | | | |
| Striped Kingfisher | | | | | | | | | | | | 1 | | | | | | | | |
| Tawny-flanked Prinia | | | | | | | | | | | | | | | | | | | | |
| Village Weaver | | 1 | | | | 1 | 1 | | | 1 | | | | 1 | | | | 1 | | |
| Village Widowfinch | | | | | | | | | | | | | | | | | | | | |
| White-browed Robin-Chat | | | | 1 | | | | | | | | | | | | | | | | |
| White-browed Scrub-Robin | | | | | | | | | | | | | | | | | | | | |
| White-fronted Bee-eater | | | | | 1 | | | | | 1 | | | | | 1 | | | | | |
| Woolly-necked Stock | 1 | | | | | | | | | | | | 1 | | | | | | | 1 |
| Yellow-breasted Apalis | | | | | | | | | | | | | | | | | | | | |
| Yellow-fronted Canary | | 1 | | | 1 | | | | 1 | | | 1 | | 1 | | 1 | | | | |
| Yellow-throated Petronia | | | 1 | | 1 | | 1 | | | | 1 | | 1 | | 1 | | 1 | | 1 | |

**Appedix 3.3 cont.:** *Presence absence data of birds in thickets (T), low density woodland (L), medium density woodland and (M) and high density (H).*

| Common name | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | H1 | H2 | H3 | H4 | H5 | H6 | H7 | H8 | H9 | H10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acaica Pied Barbet | 1 | | 1 | | | | | | | | | | | | | | | | | |
| African Hoopoe | | | | | | | | | | | | | | | | | | | | |
| African Paradise Flycatcher | | | | | | | | | | | | 1 | 1 | | 1 | | 1 | | | |
| Black-backed Puffback | | | 1 | | 1 | | | | 1 | | 1 | | | | 1 | 1 | | | | |
| Black-bellied Bustard | | | | | | | | | | | | | | | | | | | | |
| Black-collared Barbet | | 1 | | 1 | | | 1 | | | | | | | | | | | | | |
| Blue Waxbili | | | | | | | | | 1 | | | | | | | 1 | | | | |
| Brown-crowned Tchagra | | | | 1 | | | 1 | | | | | | 1 | | | | | 1 | 1 | 1 |
| Brown-hooded Kingfisher | | | | | | | | | | | | | | | | | | | | |
| Brubru | | | 1 | | | | | | | | | 1 | | | | | 1 | | 1 | 1 |
| Buhveld Pipit | | | | 1 | | 1 | | 1 | | | 1 | | | 1 | | | | | | |
| Burcell's Coucal | | | | | | | | | | | | | | | | | | | | |
| Cape Glossy Starling | 1 | | | 1 | | | 1 | | | | | | | | | | | | | |
| Cape Turtle Dove | | | 1 | | | | | | | | | | | | | 1 | | | | |
| Cape White-eye | | | | | | | | | | | | | 1 | | | 1 | | 1 | | 1 |
| Chinspot Batis | | | 1 | | 1 | | | 1 | | 1 | | | | | 1 | 1 | | | | |
| Commmon Fiscal | | | | | | | | | | | | | | | | | | | | |
| Common Scimitarbill | | | | | 1 | | 1 | | | | | | | | | | | | | |
| Common Waxbill | | | 1 | | | | 1 | | | 1 | | | | | | | | | | |
| Crested Barbet | 1 | | | | | 1 | | | | | | | | | | | | | | |
| Crested Francolin | | | | | | | | | | | | | | | | | | | | |
| Dark-capped Bulbul | | 1 | 1 | | | | | | | 1 | | | | 1 | | 1 | | | 1 | |
| Eastern Nicator | | 1 | 1 | | | | 1 | | | | | | 1 | | 1 | | | 1 | 1 | |
| Emerald-spotted Dove | | 1 | 1 | | 1 | | 1 | | | | 1 | | | | | | | | | |
| European Roller | | | | | | | | | | | | | | | | | | | | |
| Fork-tailed Drongo | 1 | | | | | | | | | | | | | | | | | | | |
| Golden-breatsed Bunting | | | 1 | | | | | 1 | | | | | | 1 | | | | | | |
| Golden-tailed Woodpecker | | | | | | | 1 | | | | | | | | | | | | | |
| Greater Honeyguide | | | | | 1 | 1 | | | | | | | | | | | | | | |
| Green Wood-Hoopoe | | | | | 1 | | | | 1 | | | | | | | 1 | | | | |
| Green-back Camaroptera | | | 1 | | | | | | | | | | | | 1 | | | | 1 | |
| Grey-headed Bush Shrike | | | 1 | | | | | | | | | | | | | 1 | | | | |
| Hadeda Ibis | | | | | | | | | | | | | | | | | | | 1 | |
| Helmeted Guineafowl | | | | | | | | | | | | | | | | | | | | |
| Klaas's Cuckoo | | 1 | | | | | | | | | | | | | | | | | | |
| Lilac-breasted Roller | | | | | | | | | | | | | | | | | | | | |
| Little Bee-eater | | | | | | | | | | | | | | | | | | | | |
| Long-billed Crombec | | | | | | | 1 | | 1 | | | | | | | | 1 | | 1 | |
| Magpie Shrike | | | | | | | | | | | | | | | | | | | | |
| Natal Francolin | | | | | | | | | | | | | | | | | | | | |
| Purple-crested Turaco | | 1 | 1 | | | | | | | | | | | | | | | | | |
| Rattling Cisticola | 1 | 1 | 1 | 1 | | 1 | | 1 | | 1 | | 1 | | | | 1 | 1 | | | |
| Red-backed Shrike | | | | | | | | | | | | | | | | | | | | |
| Red-billed Firefinch | | | | | | | | | | | | 1 | | 1 | | | 1 | | 1 | |
| Red-billed Quelea | | | | | | | | 1 | | | | | | | | | | | | |
| Red-faced Mousebird | | | 4 | | | | 1 | | | | | | | | | 1 | | | | |
| Red-fronted Tinkerbird | | 1 | | | | 1 | | | 1 | | | | | | 1 | | | | | |
| Red-thorated Wryneck | | | | | | | | | | | | | | | | | | | | |
| Rudd's Apalis | | | | | | | | | | | | | 1 | | | | 1 | | | |
| Scarlet-chested Sunbird | | | 1 | | | 1 | | | | | | | 1 | | | | | | 1 | |
| Sombre Greenbul | | | 1 | | | | | | | | | | 1 | | 1 | 1 | | | 1 | |
| Southern Bald Ibis | | | | | | | | | | | | | | | | | | | | |
| Southern Black Tit | 1 | | | 1 | | | | 1 | | 1 | | | | | | | | | | |
| Southern Boubou | | | 1 | | | | | | | | | | | | | 1 | | | | 1 |
| Southern Yellow-billed Hornbill | | | | | | | | | | | | | | | | | | | | |
| Speckled Mousebird | | | | | | | | 1 | | | 1 | | 1 | | | | | | | |
| Striped Kingfisher | | | | | | | | | | | | | | | | | | | | |
| Tawny-flanked Prinia | | | | | | | | | | | | | | | | 1 | | | | |
| Village Weaver | | | | | | | | | | | | | | | | | | | | |
| Village Widowfinch | | | | | | | | | | | | 1 | | | | | 1 | | 1 | |
| White-browed Robin-Chat | | | | | | | | 1 | | | | 1 | | | | | | | | |
| White-browed Scrub-Robin | | | | | 1 | | 1 | | 1 | | | | 1 | | | | | | | |
| White-fronted Bee-eater | | | | 1 | | | | | | | | 1 | | | | | | | | |
| Woolly-necked Stock | | | | | | | | | | | | | | | | | | | | |
| Yellow-breasted Apalis | | | | | | | | | | | | | 1 | 1 | | | 1 | | | 1 |
| Yellow-fronted Canary | | 1 | | | | | | | | | 1 | | | | | | | | | |
| Yellow-throated Petronia | | | 1 | | | 1 | | | | | | | | | | | | | | |

# Chapter 4: Post-fire vegetation change and bird responses in Hluhluwe-iMfolozi Park

## *Introduction*

Fire is a natural form of disturbance of savanna ecosystems and has influenced the evolution of many organisms (Bond & Van Wilgen 1996). Its role and implementation have, however, remained contentious issues, and topics of much debate. Although a great deal of literature is available on fire in African savannas, few studies have addressed the ecological effects that fire has on bird communities. In Australia, fire is now recognised as a significant threat to many rare, vulnerable and endangered bird species (Woinarski 1999), with most of the fire-threatened species requiring fire intervals longer than those that have been imposed since European settlement (Woinarski 1999).

In HiP, two distinct grassland types occur, short stoloniferous grazing lawns and tall tussock-like bunch grasslands. Bunch grasslands burn readily due to high biomass of combustible, tall standing material. In contrast, the grazing lawns hardly support fire and are preferred by grazing animals that depend on these grasslands for high quality forage. These lawn and bunch grasslands support distinctly different avifaunal assemblages, including several short and tall grass specialists (Chapter 3). Reports suggest that grasslands as a whole have diminished in HiP (Brooks & Macdonald 1983; Macdonald 1979; Watson & Macdonald 1983a) and evidence exists that suggest that grazing lawns in particular have decreased in extent since the 1960s (Bond *et al.* 2001). This is particularly evident in Hluhluwe, were long-term monitoring has shown dramatic changes from short grass in the late 1960s to tall grass swards in the 1980s. This decrease in grazing lawns coincided with the disappearance of many grassland-frequenting bird species in the 1970s (Macdonald 1984), several of which frequented short-grass habitats. The majority of these species are known to be nomadic, migratory or on the edge of their range. However, their disappearance nonetheless strongly suggests that some change has taken place. It is possible that this change has occurred beyond the park boundaries, but it may equally well be a

response to habitat changes within the park. If the latter is the case, an understanding of the processes responsible would provide insight that may help prevent further biodiversity loss.

Studies have shown that different experimentally manipulated fire regimes may drive measurable and consistent differences in habitat structure and composition over both the short and long term (Enslin *et al.* 2000; Trollope *et al.* 1987). It has been suggested that frequent fire of intervals of less than four years, inhibits the development of grazing lawns in HiP (Archibald *et al.* 2005). After a fire event, herbivores are attracted to the post-burn flush of new growth and consequently drawn off heavily grazed patches. Very small fires may concentrate grazers which might initiate a grazing patch but the normal large fires will pull grazers off grazing patches and cause the herbivores to spread out on the large burnt areas and thus have a less concentrating effect. In the long term, frequent large fires will indirectly reduce the density and diversity of large mammal species on grazing patches, and reduce lawn grass formation because grazers would not persist in a grazing patch long enough to cause a compositional shift from tall grass to lawn grass species. Thus a high-frequency fire regime will negatively impact on the grazing lawn bird community. However, a significant link exists between grassland bird distribution and vegetation structure (Chapter 3). After a fire has burnt tall grasslands, the initial recovery is structural short grassland. The short post-burn areas may be sufficiently structurally similar to grazing lawns to support grazing lawn bird assemblage for a period of time. Should this be the case, a frequent fire regime would be beneficial for the grazing lawn bird community, as it would increase the amount of habitat available to them. These two ideas contradict one another and thus I investigated the role of post-burn habitats in HiP, to acquire a better understanding of the short-term bird responses to fire. This will help determine the importance of post-burn habitats for grazing lawn bird communities and provide insight to whether or not high or low frequency fire regimes are more beneficial.

This chapter sets out to:

1. Determine which bird species occur in bunch grassland before a fire event.
2. Determine how birds respond to a fire event.
3. Determine if a succession from short grass bird community to tall grass bird assemblage does exist, and over what time scale it is likely to occur.

## Methods

Fifteen potential sites were identified in tall bunch grassland. Each of these sites fell within the proposed burning program for the year, and thus potentially would be burnt at the end of the dry season. During July and August 2003, nine of the proposed sites burnt, five in mesic areas (Hluhluwe) and four within semi-arid savanna (iMfolozi). At each of these sites, bird and vegetation surveys were conducted 10 to 20 days before the fire event. During a fire event, observations were made of birds at the fire front; thereafter, bird and vegeta tion surveys were made at 3, 5, 7, 15, 30, 45, 60, 75, 90, 120, 180, 240 and 300 days post fire.

At each study site, two metal pegs were used to demarcate the start and end points of a 200m transect. This was to ensure the same route was traversed during each sampling period. Due to the large changes in vegetation height pre- and post fire, two different bird survey techniques were needed for short and tall grass swards. When the mean DPM reading (grass height) was greater than 5 cm, the rope drag technique was applied, when the DPM reading was less than 5 cm a standard line transect was used (see Chapter 3 for details of bird survey techniques).

At the same localities where bird data were collected, grass height was also measured. An index of grass height was obtained using a Disc Pasture Meter (Bransby & Tainton 1977). A total of 50 points were sampled per transect at two metre intervals along the first 100 m of the marked (with metal pegs) transect. This was done after each bird survey.

The probability of occurrence of each of the grassland bird specialists at different grass heights was determined using incidence functions. For example, if African Pipit was only found at eight of the nine sites when the DPM reading grass height was 2 cm, the probability of occurrence was 0.89 (8/9). Incidence curves also were constructed to examine bird presence after fire of the three short-grass specialists and the three numerically dominant tall-grass specialists. This was done at mesic (Hluhluwe) and arid (iMfolozi) sites.

## *Results*

Ten different bird species made use of the fire fronts as a hunting ground, hawking and pouncing on invertebrates and vertebrates flushed by the fire (Table 4.1).

**Table 4.1**: *Birds present and moving with the fire front, hawking or pouncing on prey items, or feeding on aerial prey above fires in Hluhluwe and iMfolozi.*

| Species | Hluhluwe | iMfolozi |
|---|---|---|
| Yellow-billed Kite | 1 | 1 |
| Jackal Buzzard | 1 | 1 |
| White-fronted Bee-eater | 1 | 1 |
| Little Bee-eater | 1 | 1 |
| Lilacbreasted Roller | | 1 |
| Southern Yellow-billed Hornbill | | 1 |
| Crowned Hornbill | 1 | |
| Fork-tailed Drongo | 1 | 1 |
| Common Fiscal | 1 | 1 |
| Cape glossy Starling | 1 | 1 |



Senegal Lapwing and Plain-backed Pipits moved into burnt areas within 2 hours of the fire event and were present for approximately 2 weeks. There was a turnover from short grass specialists to tall grass specialists in the post-burn areas. Short grass specialists were present for 50-100 days post burn, being replaced by tall grass specialists soon thereafter (Figure 4.1). In iMfolozi, where grass growth is less than Hluhluwe due to a lower rainfall, the short-grass specialists were present for longer periods (Figure 4.1).

Each of the grassland specialists showed distinct preference for a particular range of grass height (Figure 4.2/3/4). Short-grass specialists were not present before the fire; however, after the fire they were present until the grass exceeded a certain height. I

was unable to establish the grass height preference for African Stonechat due to lack of replication. Zitting Cisticola, Red-collared Widowbird and Small Buttonquail showed similar patterns to short-grass specialists in that they had a distinct grass height range preference (Zitting Cisticola 4-10 DPM units, Red-collared Widowbird 4.5-10 DPM units, Small Buttonquail 4.5-20 DPM units). When a minimum grass height was reached the birds started utilising the burnt areas. Once the grass height had exceeded a maximum threshold they moved off. The rest of the tall grass specialists appeared once the grass swards reached a minimum height, but thereafter did not show a decrease with an increase in grass height. Rufous-naped Lark and Yellow-throated Longclaw are generalists, and tolerated a broad range of grass heights.

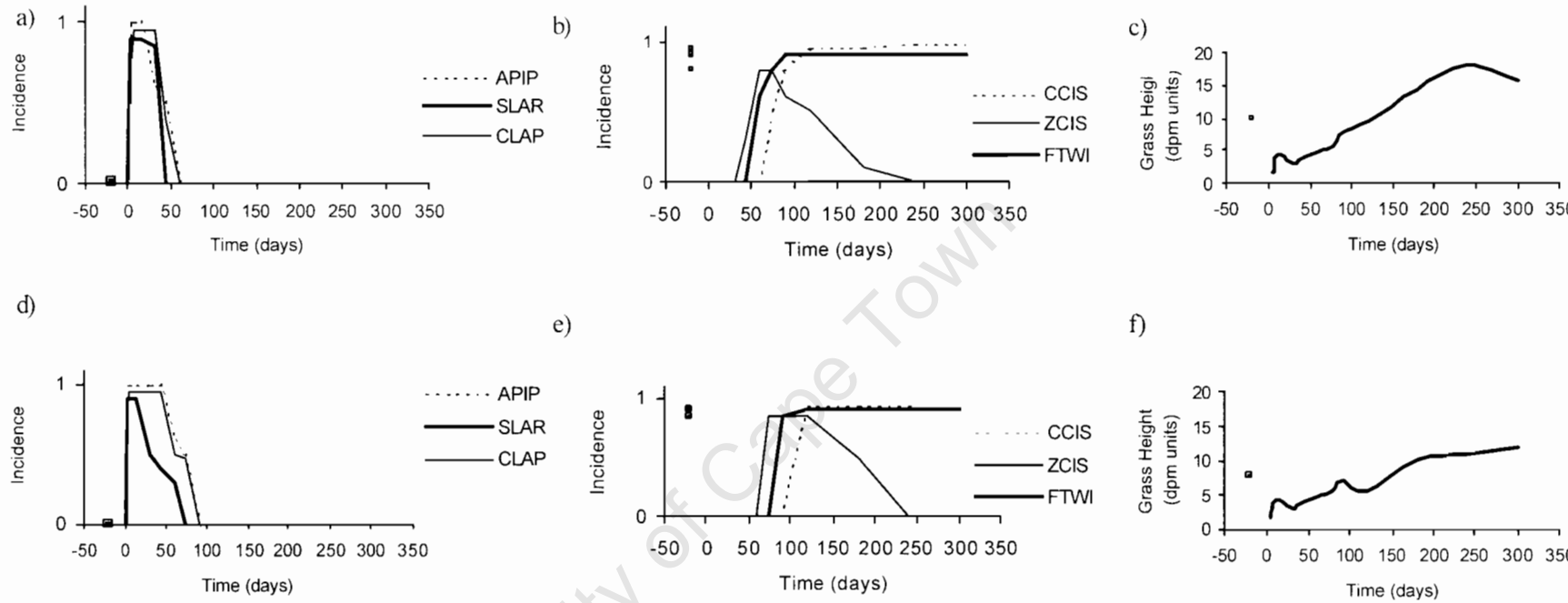




**Figure 4.1:** *Incidence curves of three short grass specialists, the three most dominant bunch grass specialists and the corresponding grass height after a fire event of four Hluhluwe sites (a,b,c). Incidence curves of three short grass specialists, the three most dominant bunch grass specialists and the corresponding grass height after a fire event of five iMfolozi sites (d,e,f). Squares represent bird incidence and grass height before fire (APIP African Pipit, SLAR Sabota Lark, CLAP Crowned lapwing, CCIS Croaking Cisticola, ZCIS Zitting Cisticola, FTWI Fan-taile Widowbird)*

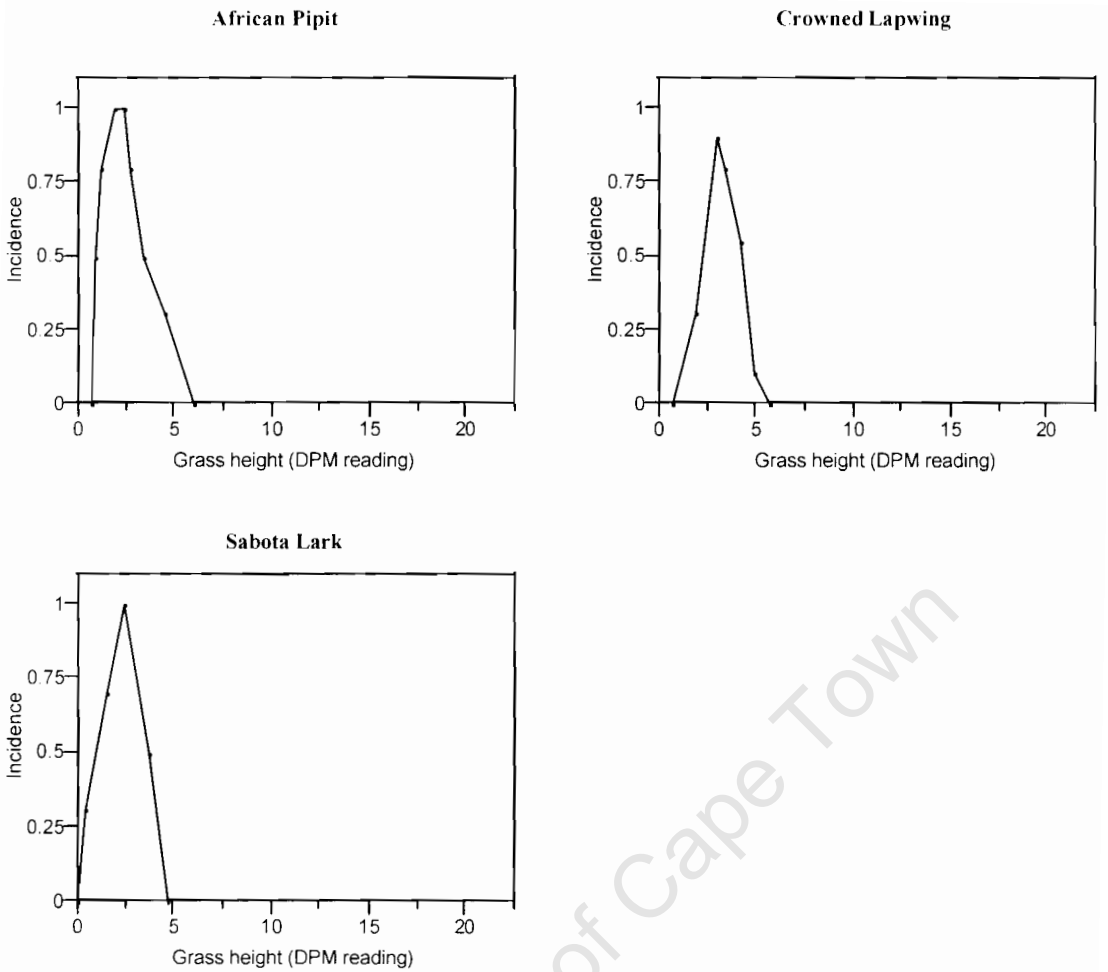


**Figure 4.2:** *Incidence curves of short grass specialists in relation to grass height. Note: The points represent the proportions of sites in which birds were present at a particular grass height.*

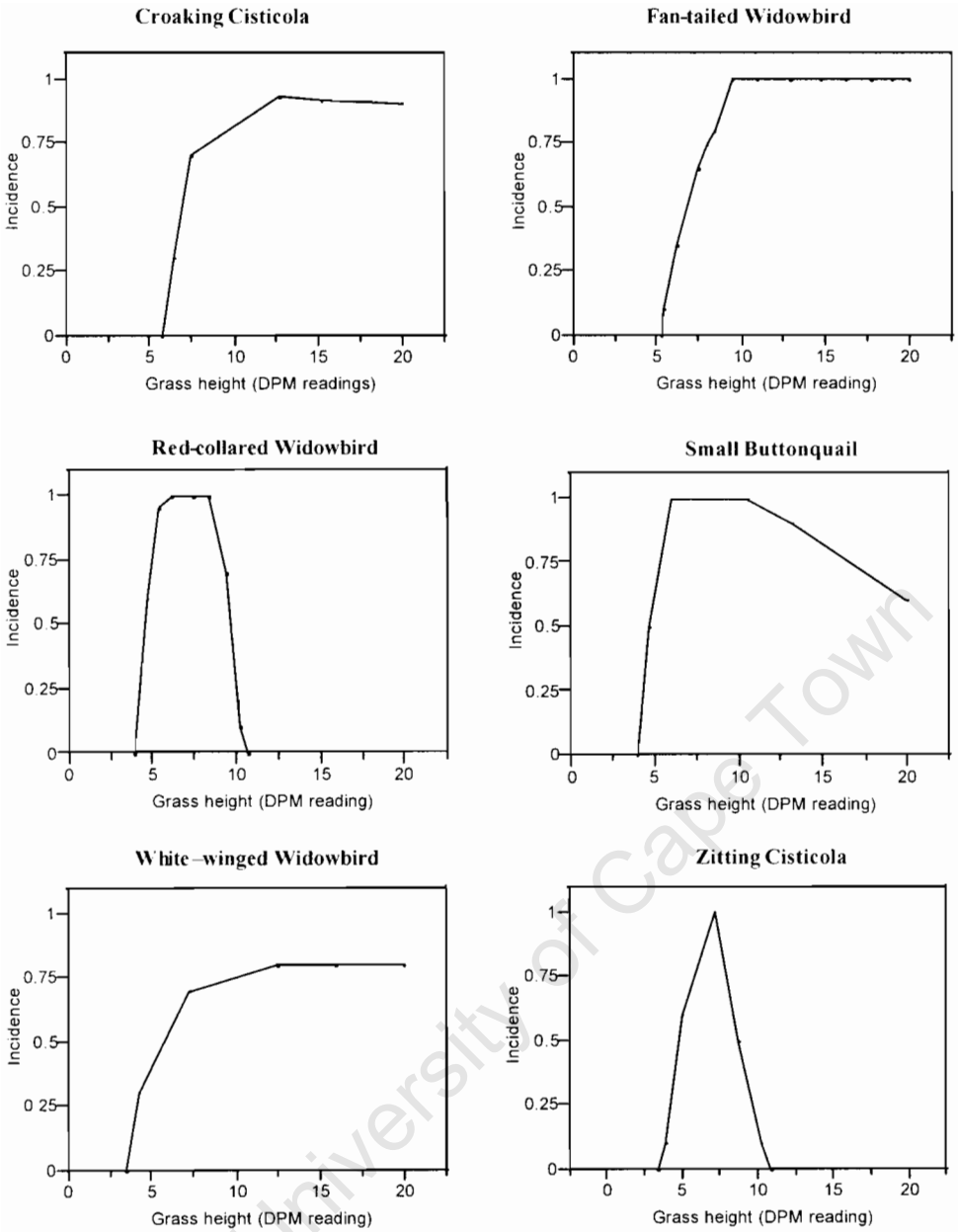




**Figure 4.3:** *Incidence curves of tall grass specialist species in relation to grass height. Note: The points represent the proportions of sites in which birds were present at a particular grass height.*

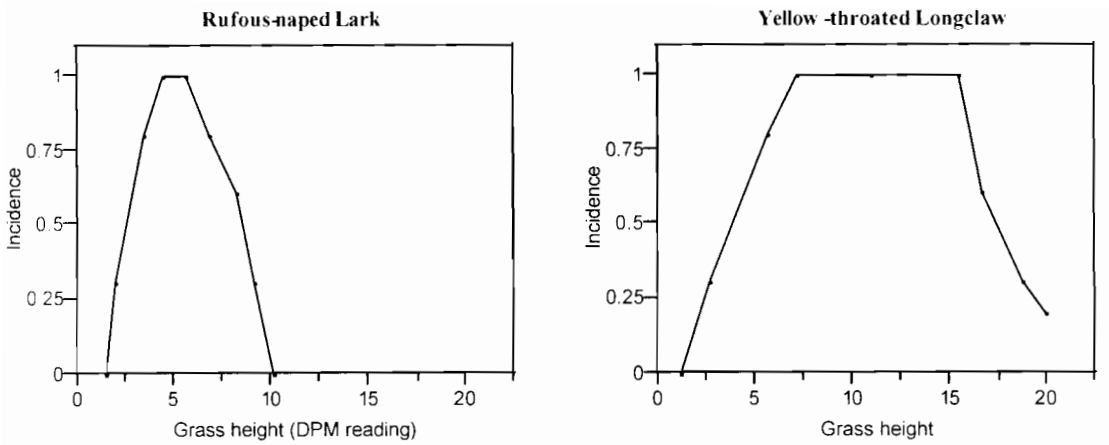


**Figure 4.4:** *Incidence curves of short and tall grass specialists in relation to grass height. Note: The points represent the proportions of sites in which birds were present at a particular grass height.*

**Table 4.2:** *Birds observed 10 to 20 days before the fire events, and birds seen 0-90, 91-180, 181-270 and 271-350 days post fire. Specialists are highlighted*

| Species | preburn | 0-90 | 91-180 | 181-270 | 271-350 |
|---|---|---|---|---|---|
| Woolly-necked Stork | | 1 | | | |
| Southern Bald Ibis | | 1 | | | |
| Hadeda Ibis | | 1 | 1 | 1 | |
| Secretarybird | | 1 | | | |
| Helmeted Guineafowl | | 1 | 1 | | |
| **Small Buttonquail** | **1** | | **1** | **1** | **1** |
| Corn Crake | | | 1 | | |
| Black-bellied Bustard | 1 | | 1 | 1 | 1 |
| **Crowned Lapwing** | | **1** | | | |
| Senegal Lapwing | | 1 | | | |
| Cape Turtle Dove | 1 | 1 | 1 | 1 | 1 |
| Emerald-spotted Dove | 1 | 1 | 1 | 1 | 1 |
| Jacobin Cuckoo | | | | 1 | |
| Burchell's Coucal | 1 | 1 | 1 | | 1 |
| Speckled Mousebird | 1 | | 1 | 1 | 1 |
| Striped Kingfisher | 1 | 1 | 1 | 1 | 1 |
| White-fronted Bee-eater | | 1 | 1 | | |
| Little Bee-eater | 1 | 1 | 1 | 1 | 1 |
| European Roller | | | 1 | 1 | |
| Lilacbreasted Roller | | 1 | | | |
| African Hoopoe | 1 | 1 | 1 | 1 | 1 |
| Green Wood-hoopoe | 1 | 1 | | | |
| Common Scimitarbill | | 1 | | | 1 |
| Southern Yellow-billed Hornbill | | 1 | | | |
| Southern Ground-hornbill | | 1 | | | |
| Black-collared Barbet | | 1 | | | 1 |
| Acacia Pied Barbet | 1 | 1 | 1 | 1 | 1 |
| Crested Barbet | | | | | 1 |
| Greater Honeyguide | | | 1 | | 1 |
| Golden-tailed Woodpecker | | 1 | | 1 | |
| Cardinal Woodpacker | | 1 | | | |
| Red-faced Mousebird | 1 | 1 | 1 | 1 | 1 |
| **Rufous-naped Lark** | **1** | **1** | **1** | **1** | **1** |
| Flappet Lark | 1 | | 1 | 1 | 1 |
| **Sabota Lark** | | **1** | | | |
| Black Cuckooshrike | 1 | 1 | 1 | 1 | 1 |
| Fork-tailed Drongo | 1 | 1 | 1 | 1 | 1 |
| Black-headed Oriole | | 1 | | | 1 |

***Table 4.2 cont.:*** *Birds observed 10 to 20 days before the fire events, and birds seen 0-90, 91-180, 181-270 and 271-350 days post fire. Specialists are highlighted*

| Species | preburn | 0-90 | 91-180 | 181-270 | 271-350 |
|---|---|---|---|---|---|
| Southern Black tit | 1 | 1 | 1 | 1 | 1 |
| Green-winged Pytilia | | 1 | | | |
| Dark-capped Bulbul | 1 | 1 | 1 | 1 | 1 |
| Kurrichane Thrush | | 1 | 1 | | |
| **African Stonechat** | | | | | **1** |
| White-browed Scrub-Robin | | 1 | | 1 | |
| Longbilled Crombec | 1 | | | 1 | 1 |
| **Zitting Cisticola** | **1** | | **1** | **1** | |
| Rattling Cisticola | 1 | 1 | 1 | 1 | 1 |
| **Croaking Cisticola** | **1** | | **1** | **1** | **1** |
| Southern Black Flycatcher | | 1 | 1 | | |
| Pale Flycatcher | | 1 | | | |
| Fiscal Flycatcher | | 1 | | | |
| Chinspot Batis | 1 | 1 | 1 | 1 | |
| **African Pipit** | | **1** | | | |
| Plain-backed Pipit | | 1 | | | |
| **Yellow-throated Longclaw** | **1** | **1** | **1** | **1** | **1** |
| Common Fiscal | 1 | 1 | 1 | 1 | 1 |
| Red-backed Shrike | | | | 1 | |
| Black-backed Puffback | | 1 | | 1 | |
| Brubru | 1 | 1 | 1 | 1 | 1 |
| Black-crowned Tchagra | 1 | 1 | 1 | | 1 |
| Brown-crowned Tchagra | | | | 1 | |
| Orange-breasted Bush Shrike | | | | | 1 |
| Violet-backed Starling | 1 | 1 | 1 | 1 | 1 |
| Cape glossy Starling | 1 | 1 | 1 | 1 | 1 |
| Marico Sunbird | | | 1 | 1 | |
| White-bellied Sunbird | | | | 1 | |
| Scarlet-chested Sunbird | | | 1 | 1 | |
| Southern Grey-headed Sparrow | | 1 | | | |
| Yellow-throated Petronia | | 1 | 1 | 1 | |
| Village Weaver | | 1 | | | |
| Red-billed Quelea | | 1 | | | |
| **Fan-tailed Widowbird** | **1** | | **1** | **1** | **1** |
| **White-winged Widowbird** | **1** | | **1** | **1** | **1** |
| **Red-collared Widowbird** | | | **1** | | **1** |
| Blue Waxbill | 1 | 1 | 1 | 1 | 1 |
| Common Waxbill | | | 1 | | |
| Pin-tailed Whydah | | 1 | 1 | | |
| Long-tailed Paradise-Whydah | | | 1 | | |
| Yellow-fronted Canary | | 1 | 1 | 1 | |
| Golden-breasted Bunting | 1 | 1 | 1 | 1 | 1 |

## Discussion

A number of African bird species are known have clear associations with fire. Fire fronts are used opportunistically to feed on fleeing insects (Dean 1987; Frost 1984), while post-burn habitats are used for breeding and feeding (Dean 1987; Frost 1984; Tarboton 2001). Certain species are known to be almost entirely restricted to early post burn areas, either for feeding or breeding (Frost 1984). This habitat may provide important and unique conditions for these species and be vital for maintaining populations (Hutto 1995). In HiP, small raptors and insectivorous birds followed the fire front with Fork-tailed Drongo and Yellow-billed Kite being the most numerous.

Senegal Lapwing and Plain-backed Pipits appeared shortly after the fire event. Both these species are known to feed and nest on recently burnt grasslands (Tarboton 2001). It is unlikely that they were breeding because both species were only present for approximately two weeks after the fire. Thus they were probably feeding on invertebrates and small vertebrates that were killed and exposed by the fire.

All tall grass specialists (with the exception of Red-collared Widowbird) were present before the fire event. After the fire event the regrowth vegetation was short and was colonised by short-grass inhabiting species. All short-grass specialists were present, but only for a relatively short time. Areas in iMfolozi (arid) were available for longer than in Hluhluwe (mesic) due to slower growth rates of grasses. A shift from short grass species to species more reliant on tall grass swards took place; within three months short grass specialists had been replaced by tall grass specialists.

Post-fire habitats recovered quickly and only created ephemeral habitats for short-grass specialists. A high-frequency fire regime may benefit insectivorous species feeding at the fire front and species that rely on fire for breeding and feeding. However species that feed at the fire front do so opportunistically and do not depend on fire fronts as their only food source. Species breeding and feeding in post burn areas tend to be highly mobile, enabling them to locate suitable breeding habitat irrespective of the fire management strategy employed, other than complete suppression (Mills 2003). Thus, it seems unlikely that these species will be affected by changes in fire frequency regimes. It would thus be more beneficial for the park to implement a fire management policy with low-frequency

fires, because a high-frequency regime would reduce the formation of grazing lawns (Archibald *et al* 2005), which is currently the only long-term sustainable habitat known to be available for short-grass specialists in the park.

More work relating to the ecological effect of fire on African avifauna is needed, to ensure that African avifauna does not fall into the same trap as the Australian avifauna, with some species already extinct and many others negatively affected by high-frequency fire regimes (Woinarski 1999). It would be particularly interesting to explore spatial variability in the fire regime and whether fire refugia are important for some bird species.

# Chapter 5: Comparing grassland avifauna within HiP with surrounding communal lands

## *Introduction*

Although Hluhluwe-iMfolozi Park (HiP) consists mostly of savanna woodlands (Whateley & Porter 1983), a mosaic of short and tall grasslands do occur. These two alternate grassland types not only provide a valuable food source for indigenous savanna herbivores but also provide an important habitat for birds. They support many generalist species and several short and tall grass specialists (Chapter 3). Outside the park, in the adjacent communal areas, domestic livestock has replaced savanna herbivores and much of the land has been altered by agriculture. Many of the savanna woodlands have been transformed into grasslands due to the high demand of trees for firewood and building material (Gjlbertson, pers comm.), resulting in a landscape with large expanses of short and tall grasslands, agricultural lands and rural settlements.

Because of the different land use practises outside the park, the grasslands inside and outside the park may be floristically and structurally different. In this chapter, I compare the grasslands outside the park with those inside the park with a particular emphasis on the short grass areas, as they may provide an alternative habitat for the short grass bird community dependent on the decreasing grazing lawns. If grasslands outside the park do support similar bird species, then they would be important for the overall conservation of grassland bird species. If 'overgrazed' communally farmed areas do not support these grassland bird species, then HiP would be important for the conservation of grassland birds on a regional scale. It would also highlight the need to conserve the remaining grasslands inside HiP, in particular grazing lawns.

This chapter sets out to determine:

1. If short and tall grass areas outside the park are floristically similar to those inside HiP.
2. If short and tall grass areas outside the park are structurally similar to those inside HiP.

3. If short and tall grass areas outside the park support a similar avifaunal assemblage to those inside HiP.

## *Methods*

Study sites inside and outside HiP were used to compare grassland avifauna found inside HiP to that of the communal lands surrounding the park. Matched sites close to one another would have been ideal, however the distribution of grasslands within HiP did not allow for such a comparison. I therefore used the 24 sites already identified within the park (Chapter 3). Half of these sites were predominantly short-grass swards and the other half tall grass swards. Thirty sites were selected in the surrounding communal land, with half of the sites being short grass areas and the other half tall grass areas. The grassland patches ranged from 1 to 79 hectares in size and were marked with a fixed transect that traverses the longest axis. The location of these sites is shown in Figure 5.1.

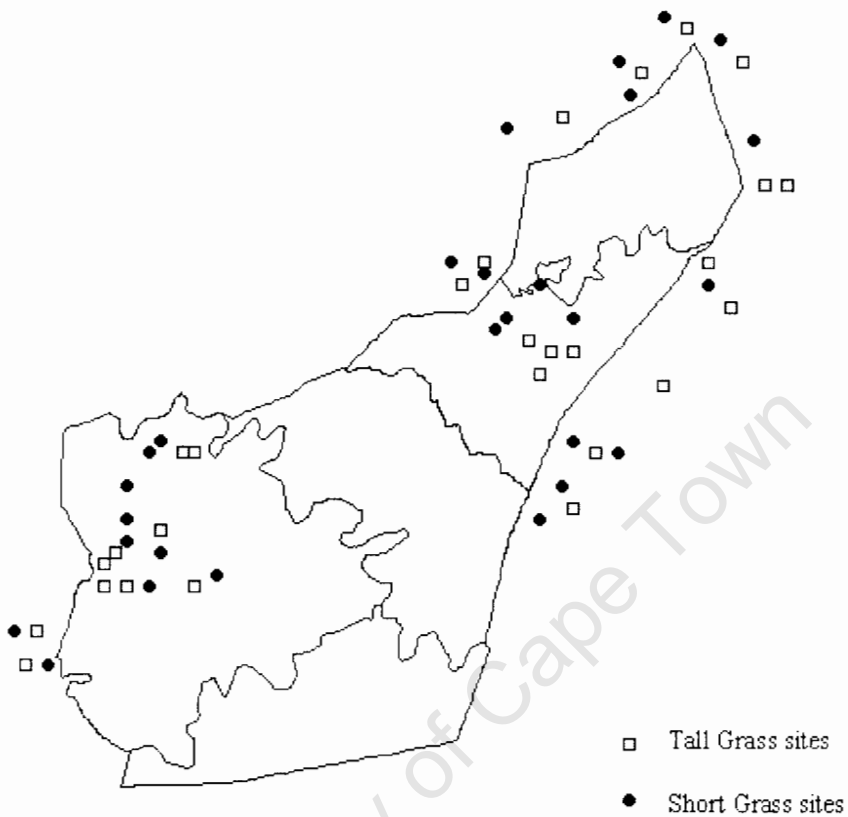




**Figure 5.1:** *Map of Hluhluwe-iMfolozi Park illustrating the study sites*

## Quantifying bird populations

The same bird survey techniques described in Chapter 3 were used to quantify bird population in the short and tall grasslands, inside and outside the park. However each site was only surveyed four times on two consecutive days in January 2004. Sampling took place during the first two hours after sunrise and the last two hours before sunset. When rain or wind appeared to affect bird activity or detectability, sampling was terminated. Data from these temporal replicates were pooled and treated as a single sample for each site.

## Characterising vegetation

At the same localities where avifaunal data was collected, a survey of the structure and species composition of the vegetation was conducted. The following data were collected at each site:

1. Grass species composition.
2. Foliage biomass.
3. Horizontal foliage diversity and bare ground.

The dominant grass species were identified at one-metre intervals along the first 100 m of the fixed transect. An index of foliage biomass was obtained using a Disc Pasture Meter (Bransby & Tainton 1977). A total of 50 data points were collected per transect at two metre intervals along the first 100 m of the fixed transect at each site. Horizontal foliage diversity of vegetation height, density and amount of bare ground were determined using the Intercept Method which gives a spatial index of bare ground, short grass swards, medium grass swards and tall grass swards (Chapter 3). Data from the Intercept Method, Foliage Biomass Index and grass species composition were collected once at each site during the study.

## Analytical methods

In tall grass sward areas, where the rope-drag techniques were used, I assumed that all birds within the strip were flushed out. Hence calculations of density were simply a matter of dividing the total number of birds seen within the strip by the strip area. Within short grass swards, the computer program DISTANCE (Laake *et al.* 1994) was used to

calculate densities. Although the techniques for estimating density in the tall and short grass swards differ, both estimate density, and thus their results are statistically comparable (see Chapter 3 for more details).

PRIMER (version 5.2.2.) was used to obtain a measure of diversity for each site, using the Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{s} p_i \log 2\ p_i$$

s = total number of species

$p_i$ = observed proportion of individuals that belong to the *i*th species

This index is influenced by the number of species present and the evenness of their distribution. Hence, increasing values of H' reflect higher species diversity. I used a Wilcoxon Test to test for differences in species number, density and diversity between the short and tall grass areas inside and outside the park.



## Results

### Grass species composition

There were differences between the grass species composition in HiP and on the adjacent communal lands (Table 5.1). Within the tall-grass areas, the sites inside the park were dominated by *Themeda triandra*. Outside the park, the majority of tall-grass sites, were dominated by *Sporobolus pyramidalis*. Short-grass sites within the park and outside the park were very similar. They were dominated by *Digitaria argyrograpta* in the south and *Digitaria longiflora* in the north. The only notable difference in the short-grass areas was that *Aristida congesta* was more prevalent in sites outside the park.

**Table 5.1:** *The relative percentage basal cover of the five most dominant grass species found inside and outside the park in tall and short grasslands*

| Inside | | Outside | |
|---|---|---|---|
| **Tall grasslands** | | | |
| *Themeda triandra* | 80 | *Sporobolus pyramidalis* | 37 |
| *Sporobolus pyramidalis* | 5 | *Themeda triandra* | 21 |
| *Bothriocloa insculpta* | 3 | *Hyparrhenia tamba* | 20 |
| *Eragrostis curvula* | 2 | *Eragrostis curvula* | 13 |
| *Hyparrhenia filiformes* | 2 | *Hyparrhenia filiformes* | 7 |
| **Short grasslands** | | | |
| *Digitaria argyrograpta* | 24 | *Digitaria longiflora* | 28 |
| *Digitaria longiflora* | 20 | *Digitaria argyrograpta* | 11 |
| *Sporobolus nitens* | 15 | *Aristida congesta* | 10 |
| *Sporobolus ioclades* | 13 | *Sporobolus nitens* | 7 |
| *Themeda triandra* | 6 | *Themeda triandra* | 6 |



## Vegetation structure

A Wilcoxon test revealed that the short grasslands outside the park were structurally very similar to the grazing lawns inside the park. The only significant difference was that the short grasslands outside the park had significantly more bare ground than the grazing lawns inside the park ($P < 0.05$). Within the tall bunch grasslands, no significant difference was revealed between grasslands outside and inside the park. The results are shown in Table 5. 2

**Table 5.2:** *A comparison of structural characteristics of short grazing lawns inside the park versus short grassland outside the park and tall grasslands inside versus tall grasslands outside the park. A Wilcoxon Test was used. The disk pasture meter reading is the settling height of the disk in cm.*

| | *n* | Inside | Outside | Z |
|---|---|---|---|---|
| **Short grass** | | | | |
| Disc pasture metre reading | 27 | 2.8 ± 0.1 | 2.75 ± 0.1 | 0.04 |
| % bare ground | 27 | 16.3 ± 1.5 | 20.7± 1.5 | -1.95 * |
| % short grass | 27 | 72.5 ± 1.6 | 71.2 ± 1.2 | 0.09 |
| % medium grass | 27 | 7.9 ± 1.5 | 6.0 ± 0.9 | 0.92 |
| % tall grass | 27 | 3.1 ± 0.9 | 1.9 ± 0.7 | 0.96 |
| **Tall grass** | | | | |
| Disc pasture metre reading | 27 | 6.1 ± 0.4 | 7.68 ± 0.7 | -1.34 |
| % bare ground | 27 | 5.8 ± 1.9 | 4.9 ± 0.9 | -0.09 |
| % short grass | 27 | 5.6 ± 2.8 | 2.3 ± 0.8 | 0.67 |
| % medium grass | 27 | 30.7 ± 4.8 | 27.0 ± 4.7 | 0.68 |
| % tall grass | 27 | 57.7 ± 5.0 | 66.3 ± 5.2 | -1.51 |

* P < 0.05 ± standard error



## Bird species composition

A total of 42 bird species were identified on the short-grass areas within HiP compared with only 21 species on the short-grass areas outside the park. The tall-grass areas inside the park supported 29 bird species and tall grasslands outside the park only 18 species. The number of birds species seen inside the park was lower than the number reported in Chapter 3, as the number reported in Chapter 3 stems from a full year of surveys while these results only reflect birds seen during January 2004.

For tall grass swards, a Wilcoxon test showed that species richness, density and species diversity on sites inside the park were significantly higher than at equivalent sites outside the park (Table 5.3). Similarly, species richness, density and species diversity on short grass swards were significantly higher inside HiP (Table 5.3).

**Table 5.3:** *Comparison between grassland birds on sites inside HiP with sites in the surrounding communal lands outside the park.*

| | *n* | Inside | Outside | Z | |
|---|---|---|---|---|---|
| **Short grass** | | | | | |
| Species richness | 27 | 9.7 ± 1.1 | 3.7 ± 0.33 | 4.06 | *** |
| Density | 27 | 6.5 ± 0.7 | 1.7 ± 0.2 | 4.02 | *** |
| Species diversity | 27 | 2.8 ± 0.1 | 1.6 ± 0.1 | 4.06 | *** |
| **Tall grass** | | | | | |
| Species richness | 27 | 6.8 ± 0.8 | 3.7 ± 0.2 | 2.97 | ** |
| Density | 27 | 10.6 ± 1.3 | 2.4 ± 0.2 | 4.27 | *** |
| Species diversity | 27 | 2.3 ± 0.2 | 1.7 ± 0.1 | 2.44 | * |

* P < 0.05 ** P < 0.01 *** P< 0.001 ± standard error

Inside the park, specialists were the numerically dominant species, outside the park the more ubiquitous species dominated (Figure 5.4 & Figure 5.5). Although there were fewer species outside the park, all grassland bird specialists were present, except for White-winged Widowbird.

**Short Grass areas**

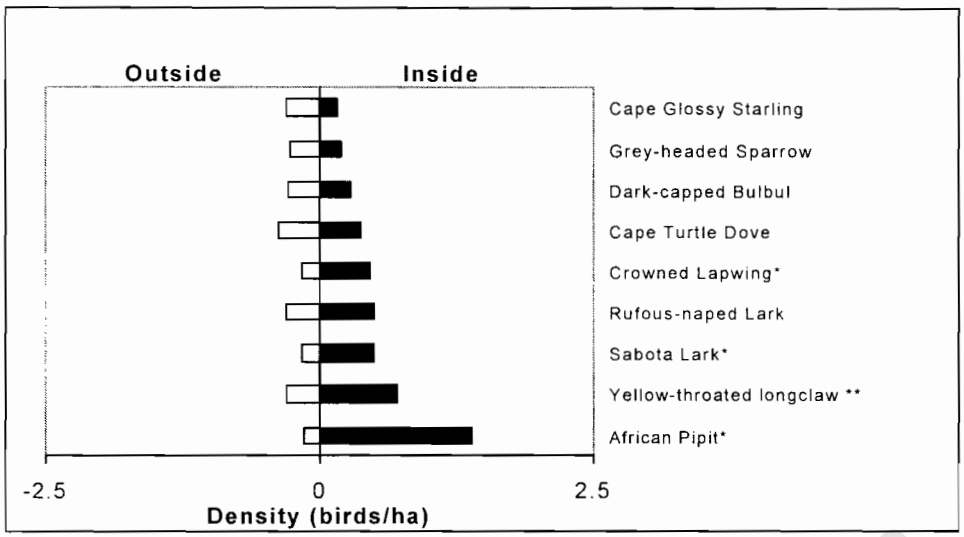


**Figure 5.4**: *Comparison of individual densities of dominant bird species in short grass areas inside and outside HiP. One star represents short grass specialists and, two stars represent grassland generalists that make use of both tall and short grass areas*

**Tall Grass areas**

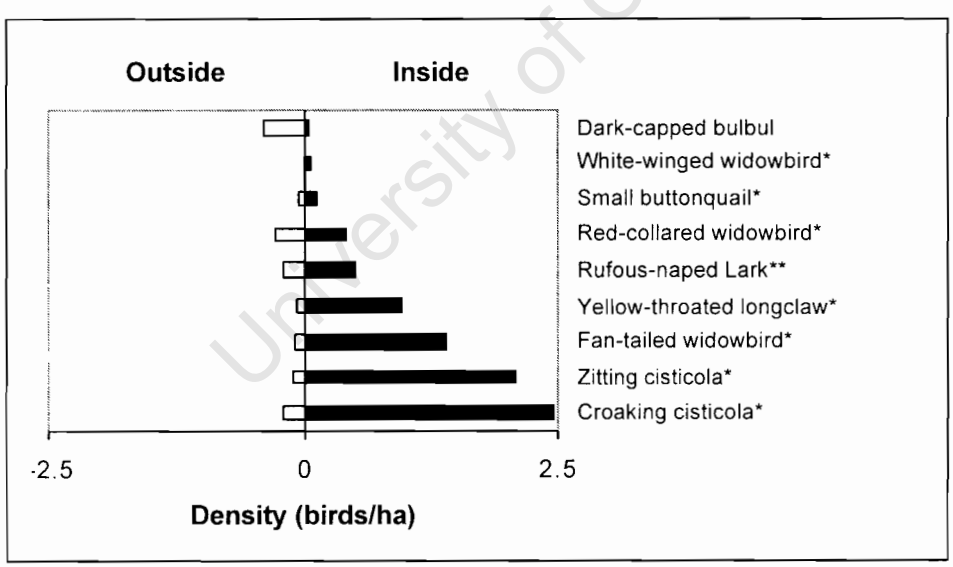


**Figure 5.5:** *Comparison of individual densities of dominant bird species in tall grass areas found inside and outside HiP. One star represents tall grass specialists; two stars represent grassland generalists that make use of both tall and short grass areas*

## Discussion

The results from this study suggest that grazing lawns inside the park and short grass areas outside the park share a similar grass species composition, with the exception of the grass species *Aristida congesta* which was more prevalent outside the park. Structurally the short grasslands are very similar, the only significant difference being that sites outside the park had a higher proportion of bare ground. Thus, with sites inside and outside the park being not only being structurally similar but also floristically similar, it was expected that sites outside the park would support similar bird communities to those found on the grazing lawns. Sites outside the park did support similar bird species, but densities outside the park were far lower than inside. Inside the park, specialists were the numerically dominant species, outside the park the more ubiquitous species dominated.

In tall grass areas, the floral compositions between bunch grassland inside and outside the park were quite different. Grasslands inside the park were dominated by *Themeda triandra*. Outside the park the dominant species was always *Sporobolus pyramidalis*. However, there was no significant structural difference. As noted in chapter 3, bird distribution is related to structure and not floral composition; thus, these grasslands should support similar species. Similar bird species were present in bunch grasslands inside and outside the park but, as in the case of the short-grass areas, the densities outside the park were very low and the bird assemblage was numerically dominated by ubiquitous species rather than by tall-grass specialists.

These results suggest that some factor is affecting the grasslands birds outside the park. The exact cause is unknown, however it has been suggested that the low densities may be related to heavy predation by people living within these areas. This is investigated in the next chapter.

# Chapter 6: Human predation on bird populations outside Hluhluwe-iMfolozi Park

## *Introduction*

Hluhluwe-iMfolozi Park is situated in the heart of Zululand, KwaZulu-Natal. Once the royal hunting grounds of King Shaka, this game reserve is now enclosed by an electric fence that separates it from the surrounding human population. The park supports a high diversity of animal and bird species, with over 400 indigenous bird species recorded. Bush encroachment, changes in fire regimes and herbivore numbers have resulted in the decrease of both tall and short grassland inside the park (Bond *et al.* 2001; Watson & Macdonald 1983b). These decreases may be linked to the local extinction of several short grass frequenting species in the 1970s (Macdonald 1984). 88 bird species still make use of the grasslands within the park. These include three short-grass specialists, seven tall-grass specialists and two grassland specialists that use both short and tall grass areas(Chapter 3).

Ironically, in the unconserved communal rangelands that surround the park, vast expanses of grassland still exist. This is probably an artefact of the continual use of trees for firewood and building material by the local inhabitants. Consequently the grasslands outside the park have not suffered from bush encroachment to the same extent as has happened inside the park. Grasslands outside the park are structurally similar (Chapter 5) and hence are predicted to support similar species. This is the case, but they occur at unexpectedly low densities. Inside the park the grassland bird specialists are numerically dominant, while outside the park, generalists dominate. The cause of these differences is unknown and may be as a result of several factors.

One possibility is human predation since discussion with people living in the surrounding communal lands revealed that birds provided a valuable source of bushmeat. Bushmeat is an important source of protein in many rural and urban households throughout Africa (Ntiamoa-Baidu 1997). In areas where wildlife still exists, people collect, hunt or purchase and eat bushmeat for a variety of reasons. Some people depend on bushmeat for their animal protein supply because they have no alternate source or cannot afford alternative sources; others eat bushmeat as a matter of preference or as a delicacy to be

eaten on special occasions. For such people, wild animals constitute a valuable food resource that cannot be easily withdrawn or replaced without causing wide-ranging socio economic imbalances (Ntiamoa-Baidu 1997). This is particularly true in sub-Saharan Africa, where bushmeat is often the primary source of dietary protein (Anadu *et al.* 1988; Asibey 1977; Geist 1988; Juste *et al.* 1995; Martin 1983)

In this chapter I investigate the extent of bird hunting and egg harvesting in the communal lands surrounding HiP, as it may provide valuable insight and help explain the low bird densities outside the park.

## *Methods*

The extent to which grassland birds are being depredated by local villagers adjacent to HiP was assessed using a questionnaire survey. I trained seven local people to conduct the questionnaire survey on my behalf. This was done to encourage honest answers, as I was concerned that if I personally conducted them, the interviewee may associate me with a wildlife department and be less inclined to answer truthfully. This also allowed for the interview to be conducted in Zulu, the home language of the interviewees.

Members of local communities in the Dakaneni, Ezibayeni, Gunjaneni, Mansibomvu Mansiya, Mpanzakazi, Mpembeni, Phidsweni, Seme, Smolo and Sososo areas were visited in February 2004. A total of 136 people, 37 females and 99 males, all living within ten kilometres of the park boundary, were questioned in a single interview. The questionnaire was designed to evaluate three factors: namely to what extent are indigenous bird species and their eggs being consumed by local people, which birds species are preferred, and which techniques are used to catch the birds (Table 6.1). Additional information was also gathered regarding which cohort may be having the greatest impact.

**Table 6.1:** *Questions asked to local people living adjacent to Hluhluwe-iMfolozi Park to examine the extent of bird predation by humans.*

| |
|---|
| 1. How many birds do you harvest and eat in a year? |
| 2. How many birds eggs do you harvest and eat in a year? |
| 3a. Do you think the bird numbers have decreased? |
| 3b. Why? |
| 4. Which age class do you think harvests the most birds? |
| a. 0-20 |
| b. 21-30 |
| c. >30 |
| d. other |
| 5. What techniques are used to harvest the birds? |
| a. flush them out and kill with sticks, stones, knobkerries |
| b. traps |
| c. catapult |
| d. air rifle |
| e. other |

To avoid over - or underestimates when the interviewer requested each respondent to recall how many birds he or she had harvested/eaten over the preceding 12 month period, a series of questions regarding shorter periods were constructed. With this data in hand a calculation of the year's harvest was made, and the respondent asked if he or she felt the figure was reasonable.

A t-test was used to determine if a difference existed between the amount of birds and bird's eggs eaten by men and women. A one-way Anova was used to compare the consumption of the different age classes. For multiple response questions (Table 1, questions 4 and 5) I reported the results as a percentage based on the total number of people surveyed. In some cases more than one response was given, hence the results do not add up to 100. The answers to open-ended questions were summarised.

Estimates of the total population living around the park were taken from a 1999 census undertaken by the African Centre (Gjlbertson 1999). These census results were used to estimate how many birds were being consumed by the total population living around the park.

## Results

A total of 136 people were questioned, 37 females and 99 males. The age varied from 7 to 72 years. At least 68 bird species were hunted for food in the study area, 9 of which were grassland specialists identified in Chapter 3 and two red data species: Grey Crowned Crane and Southern Bald Ibis (Table 6.2). Both these species are considered *Vulnerable* in South Africa (Barnes 2000).

Eggs of 20 species were collected, including 2 grassland specialists (Table 6.2). The occasional hunting of chicks and adults from the nest was also reported by the local people.

A total of 6 787 birds were estimated to have been consumed in the year 2003 by the 136 people surveyed. Average consumption was 50 (10 lower quartile, 100 upper quartile) birds per person per year and 3 (0 lower quartile, 5 upper quartile) eggs per year. A comparison of consumption by men and women suggested that men ate significantly more birds per year (men = 66 women = 7 $P < 0.001$) with no significant difference in egg consumption (Table 6.3). This was supported by comments made by several interviewees, in which it was mentioned that men actively go out and hunt birds and women only eat them when they are given a bird as a gift from a male family member. More than 25 percent of all people surveyed consumed more than 100 birds per year, with the highest harvest estimated at 250 birds per year.

People aged 21-30 consumed significantly more birds than those of other ages. This was supported by comments from the local people in which 73 percent of the people reported that the age class 21-30 harvested the most birds (Table 6.4).

**Table 6.2** . *List of all birds and bird's eggs reported to have been consumed from a questionnaire survey done in the communal areas surrounding Hluhluwe-iMfolozi Park. Grassland specialists are highlighted.*

| Birds eaten | Eggs eaten |
|---|---|
| Hamerkop | 1 |
| White Stork | |
| Southern Bald Ibis | |
| Hadeda Ibis | |
| Egyptian Goose | 1 |
| Secretarybird | |
| Yellow-billed Kite | |
| Steppe Buzzard | |
| African Marsh-Harrier | |
| Natal Francolin | |
| Helmeted Guineafowl | 1 |
| Crested Guineafowl | 1 |
| **Small Buttonquail** | **1** |
| Grey Crowned Crane | |
| **Crowned Lapwing** | **1** |
| Spotted Thick-knee | 1 |
| Cape Turtle Dove | 1 |
| Emerald-spotted Dove | |
| African Green-Pigeon | |
| Purple-crested Turaco | |
| Red-chested Cuckoo | |
| Burchell's Coucal | |
| African Wood-Owl | 1 |
| Fiery-necked Nightjar | |
| Speckled Mousebird | |
| Brown-hooded Kingfisher | |
| Striped Kingfisher | |
| African Hoopoe | |
| Crowned Hornbill | |
| Golden-tailed Woodpecker | |
| **Rufous-naped Lark** | |
| Flappet Lark | 1 |
| **Sabota Lark** | |
| Barn Swallow | |
| Fork-tailed Drongo | |
| Black-headed Oriole | |
| White-necked Raven | |
| Dark-capped Bulbul | 1 |
| Sombre Greenbul | |
| Red-capped Robin-chat | |
| Green-backed Camaroptera | |
| **Zitting Cisticola** | |
| Rattling Cisticola | |
| **Croaking Cisticola** | |
| Tawny-flanked Prinia | 1 |
| Pale Flycatcher | |
| Chinspot Batis | |
| **African Pipit** | |
| **Yellow-throated Longclaw** | **1** |
| Common Fiscal | 1 |
| Red-backed Shrike | |
| Violet-backed Starling | |
| Cape glossy Starling | 1 |
| Red-winged Starling | |
| White-bellied Sunbird | 1 |
| Scarlet-chested Sunbird | |
| Collared Sunbird | |
| Cape White-eye | 1 |
| Southern Grey-headed Sparrow | |
| Village Weaver | 1 |
| Southern Masked Weaver | 1 |
| Red-billed Quelea | |
| Southern Red Bishop | |
| **Fan-tailed Widowbird** | |
| Green-winged Pytilia | |
| Blue Waxbill | |
| Yellow-fronted Canary | |

**Table 6.3:** *The mean number of birds and eggs eaten over a 12 month period, by men and women of different age classes from in the communal area surrounding Hluhluwe-iMfolozi Park.*

| Age Class | Birds eaten | | Eggs eaten | |
|---|---|---|---|---|
| | Women | Men | Women | Men |
| 0-20 | 7.6 ± 1.4 | 56.4 ± 1.0 | 2.8 ± 1.0 | 2.7 ± 0.5 |
| 21-30 | 7.5 ± 1.5 | 138.6 ± 7.8 | 1.2 ± 0.6 | 6.4 ± 2.3 |
| >30 | 6.5 ± 1.4 | 45.0 ± 8.9 | 1.4 ± 0.5 | 3.2 ± 0.8 |

**Table 6.4:** *Response to questions regarding age group responsible for the majority of hunting and hunting techniques used.*

| Question | Response | Frequency |
|---|---|---|
| 4 | 0-20 | 22 |
| | 21-30 | 73 |
| | >30 | 5 |
| | other | 0 |
| 5 | flush | 67 |
| | traps | 53 |
| | catapult | 21 |
| | air rifle | 9 |
| | other | 0 |



The most common hunting techniques used were to flush the birds and then kill them with sticks, stones and knobkerries (67%). This was done with the aid of hunting dogs or by several people walking 10 m abreast and driving the birds out. During such hunting sessions, hunters would often return with 20 or more birds. This technique was favoured during the summer month, while traps were used mainly during the winter months. The majority of traps described were set on the ground, thus targeting ground-dwelling species; however, traps were occasionally set in trees (Figure 6.1). The sap from mistletoes (Locanthaceae) was used as an adhesive to trap perching birds. Trees in fruit provided easy hunting ground, as many frugivores were easily shot with air rifles and catapults when they fed in such trees.

**Figure 6.1:** *A selection of traps used to catch birds in the communal lands surrounding Hluhluwe-iMfolozi Park.*

## Discussion

Human activities or 'anthropogenic factors' have had a dramatic impact on birds in South Africa, from deliberate and accidental poisoning to active hunting by farmers. There are several large raptor species that now have their only viable populations inside large protected areas (Kruger National Park, Kalagadi Transfontier Park, Ndumo, St Lucia, Hluhluwe-iMfolozi Park and Mkuzi), and have become virtually extinct outside them (Barnes *et al.* 2001). Many ground-nesting species also show distinct distribution 'gaps' over Lesotho and the former Transkei, both areas with dense human populations of rural people. These gaps are clearly due to anthropogenic factors though it is not clear whether the absence of the birds is caused by direct exploitation or incidental disturbance by people and livestock, or both (Barnes *et al.* 2001). The findings of this study suggest that bird populations in the communal areas surrounding HiP are also experiencing similar anthropogenic pressure. The human depredation of birds is rife in these communal areas, with egg harvesting also taking place but on a much smaller scale.

Sixty-eight bird species were reported to have been consumed. The survey did not reveal which species were the most heavily exploited, but the hunting techniques used targeted certain guilds more than others. The primary hunting technique of flushing birds with dogs or people was conducted in open landscapes such as grasslands with few trees. I would thus expect that birds that make use of the grasslands are at greatest risk. Similarly the second most common form of hunting was that of setting traps. Traps were usually placed on the ground, targeting ground-feeding species, which would once again include several grassland-frequenting species. The persistence of such hunting activities would have a greater effect on the grassland specialists than on generalists, as the specialists are limited to the grasslands for feeding, breeding and roosting, unlike the generalists that make use of a wide range of habitats to fulfil these roles. Thus I would expect generalist species to be more resilient towards such activities, which may explain why generalists were numerically dominant over specialists outside the park.

As from 2001, South Africans no longer required a license to own an air rifle. Rifles, together with catapults, are used to kill frugivores feeding on trees in fruit. Consequently frugivores are another guild at risk. The susceptibility to human predation may also be

related to body size. A larger bird would be chosen over a smaller bird as it provides greater benefit (more food). Being of a large size makes it an easier target to hit and may also result in it being a clumsier flyer when flushed. As a result, large birds may be disproportionately at risk.

Men between the age of 20 and 30 harvested and consumed more birds than those of other age classes, with women rarely consuming birds. The average person was estimated to consume 50 birds per year, with men consuming more birds than women. The population around the park is *ca* 118 persons/km$^2$ (Gjlbertson 1999). Thus, if the findings of the questionnaire are a true reflection of bird predation, approximately 5900 birds/km$^2$ are consumed annually. By extrapolating densities displayed in Table 5.2, it is estimated that within HiP the average bird density is 650 birds/km$^2$, and outside the park it is approximately 170 bird/km$^2$. This suggests that the estimate of 5900 birds/km$^2$ may be grossly exaggerated and unreliable. This ten-fold discrepancy may lie in underestimates of bird densities, overestimates of birds eaten, or it may represent the annual harvestable surplus produced by the bird populations. The later is highly unlikely, as this would still indicate a production of almost ten times the standing stock. Bird density estimates seem reasonable; one bird in a circular patch with a radius of *ca.* 22 m inside the park compared to a patch of 43 m radius in the predated areas outside the park. The estimates of birds eaten rely entirely on the questionnaires, and clearly direct estimates of off-take are needed to help validate these estimates. It should, in principle, be possible to estimate potential annual harvest from estimates of bird population growth rates scaled, say, for different body mass of the species. An analysis of this kind might reveal that the park is an important source of birds, whereas communal areas act as a sink because of heavy predation pressure. There is very little information on demographic parameters of birds within the study areas and was therefore not possible to estimate harvestable off-take.

Given the apparent importance of birds as a supplementary food for people living in this area, it would be useful to explore the importance of the park as a potential source of birds in future research. This would help indicate whether the apparently high hunting pressure would be sustainable in the absence of a supply of birds from the adjacent protected area.

It is widely accepted that parks such as HiP are essentially for the conservation of large mammals. However as land degradation in South Africa increases, their role in

conserving other biota increases. The findings of this chapter illustrate how communal areas, though less transformed than, say, a sugar cane field, are unable to conserve avifaunal species, in particular the grassland specialists. It has highlighted the importance of HiP as a protection area within the region, as it provides a safe refuge, in which the populations can grow and then re-colonise into unprotected areas. Over the longer term, the high human pressure on natural resources such as birds may dwindle as South Africa becomes more urbanised.

# Chapter 7: The importance of large grazing lawns for grassland avifauna in Hluhluwe-iMfolozi Park

## *Introduction*

In South Africa (and elsewhere) rangeland scientists have perceived grazing lawns as products of overgrazing and mismanagement and considered tall *Themeda triandra* bunch grasslands as 'ideal veld'. The presence of 'overgrazed' patches prompted managers to reduce grazing pressure in an effort to convert short-grass areas to tall bunch grasslands. This was achieved by large-scale culling and game-capture operations. Recent studies (Zululand Grass Project, unpublished) have shown that grazing lawns are highly productive under intense grazing pressure. They are floristically different from tall bunch grasslands and support a high density and diversity of grazing herbivores. This, together with results from recent studies showing that grazing lawns support unique bird (Chapter 3) and grasshopper (Currie 2003) assemblages, suggests that they have a long evolutionary association with grazing herbivores and are thus a 'normal 'component of the African savanna.

Evidence exists to suggest that drought, fire and mammal removal may have influenced the extent of grazing lawns in HiP since the 1960s (Archibald *et al.* 2005; Bond *et al.* 2001). This is particularly evident in Hluhluwe, where long-term monitoring has shown dramatic changes from short grass in the late 1960s to tall grass swards in the 1980s. White Rhinoceroses *Ceratotherium simum* are primarily responsible for maintaining grazing lawns in the northern higher rainfall areas of HiP (MS Waldram pers. com.). Thus, even though the rhinoceros population of the park is increasing (HiP park records) removal of many animals in the late 1970s and early 1980s resulted in low densities. Removal of rhinoceroses and other grazers may have been responsible for the decrease and disappearance of grazing lawns in the northern part of the park. Archibald *et al.* (2005) have shown how fire intervals of less than four years may reduce grazing lawn formation in HiP. After a fire event, herbivores are attracted to the post-burn flush of new growth and consequently drawn off heavily grazed patches. Very small fires may concentrate grazers which might initiate a grazing patch but the normal large fires will pull grazers off grazing patches and cause the herbivores to spread out on the large burnt

areas and thus have a less concentrating effect. In the long term, frequent large fires will indirectly reduce the density and diversity of large mammals species on grazing patches, and reduce lawn grass formation because grazers would not persist in a grazing patch long enough to cause a compositional shift from tall grass to lawn grass species. Thus the historical high fire frequencies of large fires in the park may have contributed to the decrease in grazing lawns.

This decrease in grazing lawn has coincided with the local extinction of many grassland birds, several of which are dependent on short grass areas (Macdonald 1984). The reason for their disappearance is unknown, but may be linked to the decrease in grazing lawns. This effect of habitat loss and fragmentation is not new and has been documented worldwide. The majority of avian examples stem from studies in forests, showing that species richness and relative abundance of area-sensitive species decreases significantly as patch size decreases (Opdam *et al.* 1985; Robbins *et al.* 1989). Grassland studies have also shown that grassland birds are experiencing extensive population decreases because of loss of large grassland patches (Helzer & Jelinski 1999; Herkert 1994; Vickery *et al.* 1994). In a review of literature of bird and mammal responses to habitat fragmentation, Andren (1994) found that when the proportion of original habitat remaining was less than 30%, habitat fragmentation increased isolation of patches and resulted in a decrease in species richness of birds and mammals.

Very little is known on the history of grazing lawns, and the reason behind the local bird extinctions are largely speculative. However, with the realisation that grazing lawns are not overgrazed areas and artefacts of mismanagement but rather highly productive grasslands hosting unique species, the need arises to conserve grazing lawns and the biota they support. To do so, we need to know how much grazing lawn is needed, and in what configurations should they exist within the landscape to ensure persistence of the biota they support. One way to answer this would be to determine the minimum viable populations of the relevant habitat specialists and the area required to support the minimum viable population. As a first general estimate of the minimum viable population for vertebrates, Franklin (1980) and Soule (1980) suggested 500 individuals, though much larger populations (or possible smaller ones) may be required depending on species biology (Meffe & Carroll 1997).

In this chapter I attempt to determine the area of grazing lawns habitat, and its configuration, needed to sustain viable populations of birds specialising on this habitat. Because no detailed information is available on populations sizes needed to maintain viable populations, I used the Frankin-Soule estimates and ask what area of lawns is needed to conserve them sustainably in HiP.

This chapter sets out:

1. to determine which of the birds species utilising grazing lawns are sensitive to changes in patch size;
2. to determine the minimum patch size for area-sensitive species;
3. to determine the population size of area-sensitive birds in HiP
4. to determine minimum area requirements to support 500 individuals; and
5. to use this information to recommend conservation strategies for grassland birds within HiP

## *Methods*

### Field methods

The 12 short grass areas identified in chapter 3 along with all bird data collected at these sites were used in this study. The mean number of individuals of each species occurring at each site was used to test whether a species-area relationship existed. This was done by creating a scatter plot of mean bird density versus area. A range of linear and non linear equations were fitted. The best fitting curve was determined by eye and by comparing correlation coefficients. This was done using the software JMP (version 5.0.1.2.).

Helzer & Jelinski (1999), Herkert (1994) and Vickery et al. (1994) make use of the Robbins et al (1989) criteria for estimating minimum area requirements for area-sensitive grassland bird species. Due to lack of replication in my dataset, I was unable to make us of these criteria and thus devised alternative criteria. I calculated the minimum area, as the area of the smallest patch in which a particular species was seen and at which all patches larger than it also supported that particular bird species. For example, a particular species may have been observed on a patch that was 3 hectares in size, however this

species was not seen in patches that were 4 and 5 hectares in size, but was seen on a 6 hectares patch and all patches larger than 6 hectares. Therefore although the smallest patch in which this species occurred was 3 hectares, my criteria for minimum area would conclude that the 6 hectares was the minimum area. However as the sample size of patches was limited to 12, I expressed minimum area as a range of 1 hectare above and below the value calculated above. Thus I would express the minimum patch area in this example as 5 - 7 hectares.

The number of individual birds that the different size patches would support was calculated from the best-fit curve equation. These results together with information on the distribution of grazing lawn in the HiP (Archibald 2003) were used to estimate current population size of area-sensitive species and to determine how many grazing lawns of the minimum size patch would be required to support 500 individuals.

## Results

A total of 74 bird species were identified as utilising the grazing lawns. This included many ubiquitous species and five grassland specialists. A non-linear reciprocal equation best described the density versus area relationship. Six species showed a significant increase in density with increasing patch area (Table 7.1). Dark-capped Bulbul ($R^2$=0.49, P<0.01), Golden-breasted Bunting ($R^2$=0.52, P<0.01), and Rattling Cisticola ($R^2$=0.35, P<0.05) showed a significant negative relationship with a reciprocal best-fit curve. African Pipit ($R^2$=0.72, P<0.001), Crowned Lapwing ($R^2$=0.77, P<0.001) and Sabota Lark ($R^2$=0.56, P<0.01) showed a significant positive relationship with a reciprocal best-fit curve (Figure 7.1).

African Pipit required a minimum patch size of 3-5 ha, supporting 1–7 individuals. Crowned Plover required a minimum patch size of 4-6 ha, supporting 1–3 individuals. Sabota Lark required the largest minimum patch size of 6–8 ha, supporting 2–4 individuals. Thus a minimum area of *ca* 8 ha is required to support all three short grass specialists (Figure 7.1).

According to the best-fit equation a patch of 8 ha would support, 3.5 Crowned Lapwing and Sabota Lark and 13.6 African Pipit. Thus in order to support 500 individual Crowned

Lapwing and Sabota Lark, 143 grazing lawn patches of 8 ha in size would be required. Similarly 37 patches of 8 ha in size would be required to support 500 African Pipit. The cumulative total of grazing lawn required would then be 1144 ha for the former species and 296 ha for the latter.

Examination of the grazing lawns in the park from a Landsat image (Archibald 2003) revealed that in 1999, about 6897 ha (7%) of HiP consisted of grazing lawns. These consisted of 8231 patches ranging from 0.1 to 223 ha in size (Figure 7.2). A large percentage (98.3%) were smaller than 8 ha in size, and thus unable to support all three area-sensitive species. The best-fit curve equation and the minimum patch size was used to calculate the number of Crowned Lapwing, Sabota Lark and African Pipits that could occur on each patch shown on the 1999 Landsat image. It was estimated that these grazing lawns could support 2343 Crowned Lapwing, 2247 Sabota Lark and 9219 African Pipit, with the greatest proportion of the population occurring on patches greater than 25 ha (Figure 7.3).

**Table 7.1:** *The probability of bird density versus area fitting a reciprocal best-fit curve of the most abundant birds found in grazing lawns*

| Common name | F Ratio | Prob>F |
|---|---|---|
| **Positive curve** | | |
| Sabota lark | 16.420 | 0.002 ** |
| African pipit | 13.580 | 0.006 ** |
| Crowned lapwing | 7.080 | 0.032 * |
| Red-billed quelea | 1.700 | 0.220 |
| Rufous-naped lark | 1.270 | 0.302 |
| Common fiscal | 0.809 | 0.389 |
| Blue waxbill | 0.705 | 0.420 |
| Pale flycatcher | 0.566 | 0.469 |
| Fork-tailed drongo | 0.460 | 0.512 |
| Yellow-throated longclaw | 0.450 | 0.517 |
| Southern black flycatcher | 0.201 | 0.663 |
| Red-backed shrike | 0.092 | 0.768 |
| Southern grey-headed sparrow | 0.088 | 0.771 |
| Cape glossy starling | 0.038 | 0.850 |
| Cape turtle dove | 0.010 | 0.921 |
| Red-faced mousebird | 0.009 | 0.956 |
| **Negative curve** | | |
| Golden-breasted bunting | 10.910 | 0.008 ** |
| Dark-capped bulbul | 9.928 | 0.010 ** |
| Rattling cisticola | 5.400 | 0.042 * |
| Violet-backed starling | 1.090 | 0.321 |
| Yellow-throated petronia | 0.689 | 0.425 |
| Yellow-fronted canary | 0.470 | 0.508 |

* P < 0.05 ** P < 0.01 *** P < 0.001

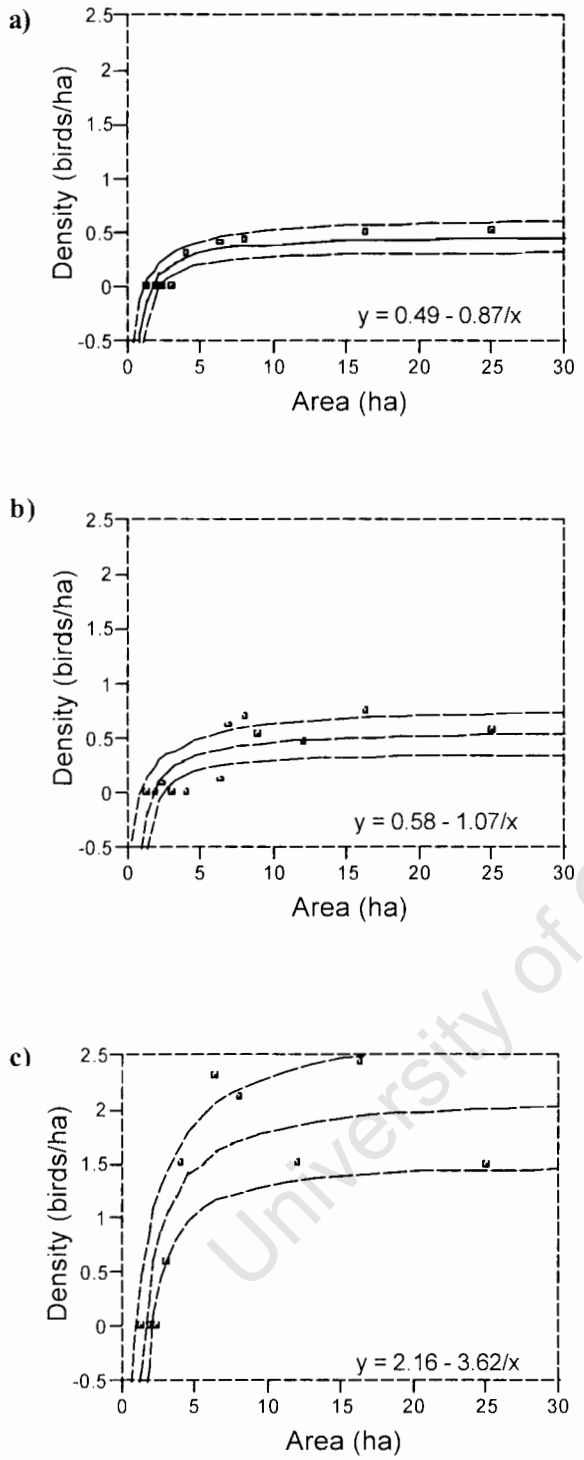




**Figure 7.1:** *Scatter plot of density of a) Crowned Lapwing, b) Sabota Lark and c) African Pipit versus area. Solid line represents a best-fit reciprocal curve. Dashed lines represent 95% confidence limits.*


**Figure 7.2:** *Frequency distribution of different sized grazing lawn patches in HiP from a 1999 Landsat image.*



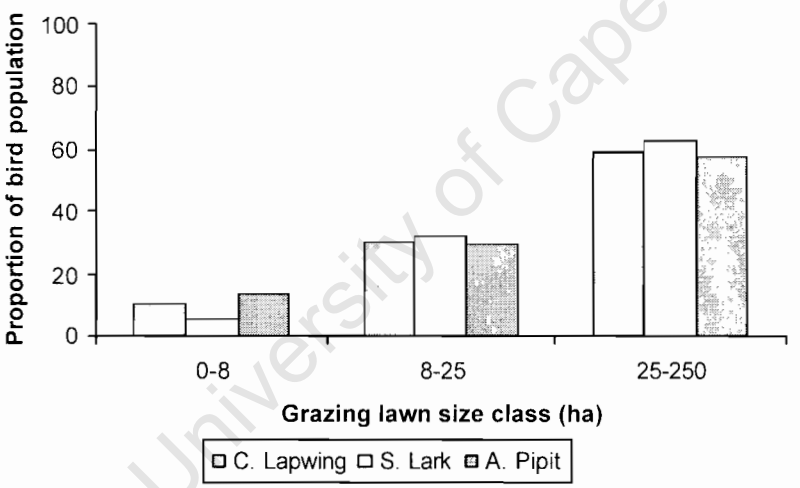


**Figure 7.3:** *The estimated proportion of total Crowned Lapwing, Sabota Lark and African Pipit populations on different size grazing lawns*

## Discussion

Grassland studies around the world have shown that grassland birds are experiencing extensive population decreases because of loss of large grassland patches (Helzer & Jelinski 1999; Herkert 1994; Vickery *et al.* 1994). In the previous chapters I have shown that even though the distribution of the short grass bird specialists in HiP is largely related to vegetation structure and not floral composition, post burn bunch grasslands and heavily grazed communally farmed areas outside the park that are structurally similar, do not provide a suitable long term habitat. The post burn grassland only provided an ephemeral habitat as grass regrowth is fast. Outside the park, dense human populations have resulted in the exploitation of indigenous species as a form of protein resulting in low bird densities. Thus in terms of the short grass bird community, HiP is effectively a biological island surrounded by a biological near-desert, and it appears that it is only the grazing lawns inside the park that can provide a sustainable habitat for the short grass specialists. Consequently the loss or decrease in these grazing lawns may result in the loss of these species from this region.

This study revealed that 74 bird species make use of grazing lawns within HiP. This includes many ubiquitous species, three short grassland specialist and two grassland specialists that make use of both short and tall grass habitats. Six species showed sensitivity to changes in area. Dark-capped Bulbul, Rattling Cisticola and Golden-breasted Bunting significantly decreased in density as the size of grassland patches increased. These species are known to have an affinity with trees and shrubs, thus their decrease in number is probably related to decrease in edge effect as patch size increases. Crowned Lapwing, Sabota Lark and African Pipit all significantly increased in density with an increase in patch size, until a minimum patch size was reached and the densities leveled off. These species are all short grass specialists (Chapter 3). The two grassland specialists that inhabit both short and tall grass areas showed no sensitivity to changes in grassland patch size. Thus I would expect Crowned Lapwing, Sabota Lark and African Pipit to be the species to be most adversely affected by habitat loss or fragmentation, should grazing lawn patch size fall below their minimum patch size requirement. .

Using the Frankin-Soule 'rule of thumb' of 500 individuals as the minimum number for a viable population, I estimated that grazing lawns greater than 8 ha in size, that

cumulatively total 1144 ha would be sufficient to support 500 Crowned Lapwing and Sabota Larks, and 296 ha for African Pipits. An examination of the grazing lawns in the park from a Landsat image (Archibald 2003), revealed that in 1999 about 6897 ha (7%) of HiP consisted of grazing lawns. However, only a small percentage of these grazing lawns are large enough to support the specialist birds, with patches > 8 ha accounting for only 1.74 % of the number of grazing lawns. Taking into account minimum patch size, and the make-up of grazing lawns in 1999, it was estimated that grazing lawns in HiP could support 2343 Crowned Lapwing, 2247 Sabota Lark and 9219 African Pipit. These figures are well above the 500 'rule of thumb'. It is interesting to note that the grazing lawns in the mesic Hluhluwe end of the park are inadequate for supporting viable populations of short grass specialists, while those in the semi-arid iMfolozi end seem more than adequate (Figure 7.4). According to this study, if, say, iMfolozi were de-proclaimed, these species would be lost from this region.

Grazing lawns seem to have been much more extensive in the mesic savannas of Hluhluwe several decades ago. It is interesting to speculate whether the short grass specialists that have gone locally extinct in this reserve were as a result of the decline of lawn areas. In order to support viable populations of the current set of three short grass specialists in Hluhluwe, managers would need to extend the lawn grass area to at least 1144 ha. It is difficult to determine the exact size and configuration of the individual patches, however the results from this study suggest that at least 143 patches of 8 ha or one or several very large patches would be necessary.

This is a first approximation of the extent of grazing lawns needed to maintain specialist bird species. It does not include aspects of the biology of birds that might be affected by the spatial configuration of lawns, or that may require multiple patches for feeding or breeding. Nonetheless it does give a first indication of the extent of grassland area required. Of course, the current extent may already be too small for some species that no longer occur in the park.



**Figure 7.4:** *Map illustrating important grazing lawns in Hluhluwe-iMfolozi Park. Dark shaded areas represent grazing lawns that are larger than 25 hectares and are important in terms of grassland bird conservation. Lightly shaded areas represent grazing lawns that are smaller than 25 hectares and are of lesser importance. (Adapted from Archibald 2003)*

# Chapter 8: Conclusion

Grassland ecologists recognise that grazing is a keystone process in maintaining the diversity of grasslands in the North American Great Plains (Collins 1992; Knapp *et al.* 1999). Shortgrass prairies evolved under intense grazing by prairie dogs *Cynomys ludovicianus* and bison *Bison bison* (Samson & Knopf 1994). Consequently the shortgrass prairie avifauna evolved to select a variety of different site characteristics, created within a landscapes receiving grazing pressure ranging from light to severe (Vickery *et al.* 2000). Unfortunately, current rangeland practises in the shortgrass prairies strive to graze rangelands uniformly. These practices have removed or inhibited heterogeneous grazing impacts across the landscapes, which do not favour the specific habitat requirements of many bird species. For example, Mountain Plovers *Charadruis montanus* require heavily grazed sites for breeding, but Lark Buntings *Calamospiza melanocorys* prefer denser vegetation (Vickery *et al.* 2000). Therefore modern rangeland grazing techniques, along with the elimination of native herbivores and widespread fire suppression are thought to be responsible for the decline in several grassland bird populations (Fuhlendorf & Engle 2001).

In Australia, where much of the megafauna no longer exists, fire plays an important role in shaping the landscape and its biota (Gill & Cathing 2001). Detrimental fire regimes may have contributed to the extinction of two of the three bird species, and three of the four subspecies that have disappeared from Australia since European colonisation. Inappropriate fire management is now a factor in the threatened status of at least 51 nationally recognised threatened bird taxa in Australia (Woinarski 1999).

In Africa, where indigenous mammalian herbivores are still an important part of natural ecosystems, grazing lawn grass communities have a bng evolutionary history with grazing mammals and are a 'normal' component of many African savannas. This has been reflected in this study on grassland avifauna in Hluhluwe-iMfolozi Park (HiP). It has shown that grazing lawns, at one end of the grassland continuum support several uniquely adapted bird species and that bunch grassland at the other end of the continuum support different uniquely adapted bird species. These species have selected a particular suite of habitat features. Crowned Lapwing, Sabota Lark and

African Pipit, for example, require the short sparse vegetation such as the grazing lawns where Small Buttonquail, African Stonechat, Zitting Cisticola, Croaking Cisticola, Fan-tailed widowbird, White-winged Widowbird and Red-collared Widowbird require taller, more dense vegetation. Some species have shown a preference to a broader range of grass types, such as Rufous-naped Lark and the Yellow-throated Longclaw that occur in both grassland types.

I found a significant link between grassland bird distribution and vegetation structure. Thus, habitats that were structurally similar to the grazing lawns, such as post-burn bunch grasslands and short grass areas created by domestic livestock outside HiP were expected to support short grass specialists. Post-burn bunch grasslands did support short grass specialist, but only for a relatively short time, as the grasslands recovered from the burn. In addition, the majority of management burns occur in July or August (HiP park records), which limits the temporal availability of such short post-burn grasslands to short grass specialists. Consequently, it is unlikely that a shifting mosaic of post fire habitats will be able to support short grass specialists year round. In the surrounding communal lands, specialists were present but bird densities were very low.

This means that in terms of short grass specialists, HiP is effectively a biological island surrounded by a biologically impoverished area with little possibility of outside areas acting as significant sources of immigrants into the park. Because fire within the park creates only ephemeral habitats, it appears that it is only the grazing lawns that provide a sustainable habitat for short grass specialists.

I attempted to predict minimum area requirements for the specialist species and related this to existing grazing lawn areas. This analysis showed that short grass specialist require grazing patches > 8 ha. However, only a small percentage of the grazing lawns in HiP are large enough to support the grazing lawn specialists, with patches > 8 ha accounting for only 1.4 % of the number of grazing lawns. My analysis also showed that the grazing lawns in the mesic Hluhluwe end of the park were inadequate to support viable populations of the birds. However the extent of short grass habitats is more than adequate in the semiarid iMfolozi end. Thus, although these specialists occur within a protected park that has been established for over 100

years, the habitat in which they occur is still at risk of habitat loss or fragmentation. The two alternate grassland types, short stoloniferous grazing lawns and tall tussock like bunch grasslands are highly dynamic. The mosaic in which they occur is determined by grazing pressure and fire regimes, both of which can and have been used as tools to manipulate the landscape (Anderson 2003; Whateley & Porter 1983). Consequently the success of these grassland specialists with different habitat preferences is highly dependent on management decisions.

For example, White Rhinoceroses *Ceratotherium simum* are primarily responsible for maintaining grazing lawns in the northern higher rainfall areas of HiP (MS Waldram pers. comm.). Thus, even though the rhinoceros population of the park is increasing (HiP park records), removal of many animals in the late 1970's and early 1980's resulted in low densities. Consequently the removal of rhinos and other grazers during this period may have been responsible for the decrease and disappearance of grazing lawns in the northern part of the park. Similarly, fire return intervals of less than fours years reduces grazing lawn formation, by indirectly reducing the density and diversity of large mammal species on grazing lawns (Archibald *et al.* 2005). As a result, the current high-frequency fire regime may have contributed to the decrease in grazing lawns.

To ensure conservation of the full complement of species in these savannas, management of these grassland areas should promote extension of grazing lawn habitat in Hluhluwe, and try to ensure that a mosaic of grassland habitat types exists throughout the park. This would ensure the availability of suitable habitat types at either end of the grassland spectrum, and would also provide habitat for birds whose preferences lie between these extremes. Further research efforts are also needed to identify critical area thresholds for other biota dependant on these grazing lawns

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# Appendix

**Appendix A:** Bird species list

| Scientific name | Common name* |
|---|---|
| *Scopus umbretta* | Hamerkop |
| *Ciconia ciconia* | White Stork |
| *Ciconia abdimii* | Abdim's Stork |
| *Ciconia episcopus* | Woolly-necked Stork |
| *Geronticus calvus* | Southern Bald Ibis |
| *Bostrychia hagedash* | Hadeda Ibis |
| *Alopochen aegyptiacus* | Egyptian Goose |
| *Sagittarius serpentarius* | Secretarybird |
| *Milvus aegyptius* | Yellow-billed Kite |
| *Buteo vulpinus* | Steppe Buzzard |
| *Buteo rufofuscus* | Jackal Buzzard |
| *Circus ranivorus* | African Marsh-Harrier |
| *Circus macrourus* | Pallid Harrier |
| *Falco rupicoloides* | Greater Kestrel |
| *Guttera pucherani* | Crested Guineafowl |
| *Pternistes natalensis* | Natal Francolin |
| *Coturnix adansonii* | Blue Quail |
| *Numida meleagris* | Helmeted Guineafowl |
| *Turnix sylvatica* | Small Buttonquail |
| *Balearica regulorum* | Grey Crowned Crane |
| *Crex crex* | Corn Crake |
| *Neotis denhami* | Denham's Bustard |
| *Neotis ludwigii* | Ludwig's Bustard |
| *Eupodotis melanogaster* | Black-bellied Bustard |
| *Charadruis tricollaris* | Three-banded Plover |
| *Vanellus coronatus* | Crowned Lapwing |
| *Vanellus lugubris* | Senegal Lapwing |
| *Burhinus capensis* | Spotted Thick-knee |
| *Cursorius temminckii* | Temminck's Courser |
| *Streptopelia capicola* | Cape Turtle-dove |
| *Turtur chalcospilos* | Emerald-spotted Wood-Dove |
| *Treron calva* | African Green-Pigeon |
| *Musophaga porphyreolopha* | Purple-crested Turaco |
| *Curculus solitarius* | Red-chested Cuckoo |
| *Oxylophus jacobinus* | Jacobin Cuckoo |
| *Chrysococcyx klaas* | Klass's Cuckoo |
| *Centropus grillii* | Black Coucal |
| *Centropus burchelli* | Burchell's Coucal |
| *Strix woodfordii* | African Wood-Owl |
| *Asio capensis* | Marsh Owl |
| *Caprimulgus pectoralis* | Fiery-necked Nightjar |
| *Colius striatus* | Speckled Mousebird |
| *Urocolius indicus* | Red-faced Mousebird |
| *Halcyon albiventris* | Brown-hooded Kingfisher |
| *Halcyon chelicuti* | Striped Kingfisher |
| *Merops bullockoides* | White-fronted Bee-eater |
| *Merops pusillus* | Little Bee-eater |
| *Coracias garrulus* | European Roller |

**Appendix A cont.:** Bird species list

| Scientific name | Common name* |
|---|---|
| *Coracias caudata* | Lilacbreasted Roller |
| *Upupa africana* | African Hoopoe |
| *Phoeniculus purpureus* | Green Wood-Hoopoe |
| *Rhinopomastus cynomelas* | Common Scimitarbill |
| *Tockus leucomelas* | Southern Yellow-billed Hornbill |
| *Tockus alboterminatus* | Crowned Hornbill |
| *Bucorvus leadbeateri* | Southern Ground-hornbill |
| *Lybius torquatus* | Black-collared Barbet |
| *Tricholaema leucomelas* | Acacia Pied Barbet |
| *Pogoniulus pusillus* | Red-fronted Tinkerbird |
| *Trachyphonus vaillantii* | Crested Barbet |
| *Indicator indicator* | Greater Honeyguide |
| *Campethera abingoni* | Golden-tailed Woodpecker |
| *Dendropicos fuscescens* | Cardinal Woodpacker |
| *Jynx ruficollis* | Red-throated Wryneck |
| *Mirafra africana* | Rufous-naped Lark |
| *Mirafra rufocinnamomea* | Flappet Lark |
| *Mirafra sabota* | Sabota Lark |
| *Calandrella cinerea* | Red-capped Lark |
| *Ereopterix leucotis* | Chestnut-backed Sparrowlark |
| *Hirundo rustica* | Barn Swallow |
| *Pseudhirundo griseopyga* | Grey-rumped Swallow |
| *Campephaga flava* | Black Cuckooshrike |
| *Dicrurus adsimilis* | Fork-tailed Drongo |
| *Oriolus larvatus* | Black-headed Oriole |
| *Corvus albus* | Pied Crow |
| *Corvus albicollis* | White-necked Raven |
| *Parus niger* | Southern Black Tit |
| *Anthoscopus caroli* | Grey Penduline-Tit |
| *Pycnonotus tricolor* | Dark-capped Bulbul |
| *Andropadus importunus* | Sombre Greenbul |
| *Nicator gularis* | Eastern Nicator |
| *Turdus libonyanus* | Kurrichane Thrush |
| *Monticola explorator* | Sentinel Rock-Thrush |
| *Oenanthe pileata* | Capped Wheatear |
| *Saxicola torquata* | African Stonechat |
| *Cossypha natalensis* | Red-capped Robin-Chat |
| *Cercotrichas leucophrys* | White-browed Scrub-robin |
| *Schoenicola brevirostris* | Broad-tailed Warbler |
| *Apalis flavida* | Yellow-breasted Apalis |
| *Apalis ruddi* | Rudd's Apalis |
| *Sylvietta rufescens* | Long-billed Crombec |
| *Eremomela icteropygialis* | Yellow-bellied Eremomela |
| *Camaroptera brachyura* | Green-backed Camaroptera |
| *Cisticola juncidis* | Zitting Cisticola |
| *Cisticola chinianus* | Rattling Cisticola |
| *Cisticola natalensis* | Croaking Cisticola |
| *Cisticola aberrans* | Lazy Cisticola |
| *Prinia subflava* | Tawny-flanked Prinia |
| *Melaenornis pammelaina* | Southern Black Flycatcher |

**Appendix A cont.:** Bird species list

| Scientific name | Common name* |
|---|---|
| *Bradornis pallidus* | Pale Flycatcher |
| *Sigelus silens* | Fiscal Flycatcher |
| *Batis molitor* | Chinspot Batis |
| *Terpsiphone viridis* | African Paradise-Flycatcher |
| *Anthus cinnamomeus* | African Pipit |
| *Anthus similis* | Long-billed Pipit |
| *Anthus leucophrys* | Plain-backed Pipit |
| *Anthus caffer* | Bushveld Pipit |
| *Macronynx croceus* | Yellow-throated Longclaw |
| *Lanius collaris* | Common Fiscal |
| *Lanius collurio* | Red-backed Shrike |
| *Corvinella melanoleuca* | Magpie Shrike |
| *Laniarius ferrugineus* | Southern Boubou |
| *Dryoscopus cubla* | Black-backed Puffback |
| *Nilaus afer* | Brubru |
| *Tchagra senegala* | Black-crowned Tchagra |
| *Tchagra australis* | Brown-crowned Tchagra |
| *Telophorus sulfureopectus* | Orange-breasted Bush Shrike |
| *Malaconotus blanchoti* | Grey-headed Bush-Shrike |
| *Cretophora cinerea* | Wattled Starling |
| *Cinnyricinclus leucogaster* | Violet-backed Starling |
| *Lamprotornis nitens* | Cape glossy Starling |
| *Onychognathus morio* | Red-winged Starling |
| *Cinnyris mariquensis* | Marico Sunbird |
| *Cinnyris talatala* | White-bellied Sunbird |
| *Chalcomitra senegalensis* | Scarlet-chested Sunbird |
| *hedydipna collaris* | Collared Sunbird |
| *Zosterops virens* | Cape White-eye |
| *Passer diffusus* | Southern Grey-headed Sparrow |
| *Petronia superciliaris* | Yellow-throated Petronia |
| *Ploceus cucullatus* | Village Weaver |
| *Ploceus velatus* | Southern Masked Weaver |
| *Quelea quelea* | Red-billed Quelea |
| *Euplectes orix* | Southern Red Bishop |
| *Euplectes axillaris* | Fan-tailed Widowbird |
| *Euplectes albonotatus* | White-winged Widowbird |
| *Euplectes ardens* | Red-collared Widowbird |
| *Phytilia melba* | Green-winged Pytilia |
| *Laganosticta senegala* | Red-billed firefinch |
| *Uraeginthus angolensis* | Blue Waxbill |
| *Estrilda astrild* | Common Waxbill |
| *Vidua macroura* | Pin-tailed Whydah |
| *Vidua paradisaea* | Long-tailed Paradise-Whydah |
| *Vidua chalybeata* | Village Indigobird |
| *Serinus mozambicus* | Yellow-fronted Canary |
| *Serinus sulphuratus* | Brimstone Canary |
| *Emberiza tahapisi* | Golden-breasted Bunting |

*Common names used by the 3rd edition Sasal Birds of southern Africa (200